

Spaceflight

The International Magazine of Space and Astronautics

Two European Astronauts In Orbit

— ♦ —
**Visit to
Space
Station**
— ♦ —

**Eleven-Day
Shuttle Mission**
— ♦ —



- Cosmodrome Visit
- Preview: Next Shuttle
- Earth Observation Plans
- Environmental Monitoring Basics

ISSN 0038-6340



The BIS Video Collection

The BIS is proud to offer a stunning record of man's exploration of space brought to your home on video.
All videos are extracted from original footage.

SPACE '93 Satellite Link-Up

A fascinating, informative chat by Arthur C. Clarke, describing his work - past, present and future, as he responds to questions put by BIS members at the Society's 60th Anniversary Meeting on 17 October 1993.

The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin. A lasting and entertaining record of a unique occasion.

The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants. 50 mins

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. 50 mins

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of the Tracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. 50 mins

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbit, removal of gantry, count-down, engine start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). This was also very successful. The video concludes with an interesting press interview with the crew. 1hr 50 mins

Giotto - Encounter With Halley

This ESA video covers the history of the famous comet from its earliest sightings to ESA's Giotto mission that flew within 600 km of the icy body in 1986. 58 mins

Ulysses, The Movie

In this ESA video, superb computer graphics describe the mission of the ESA/NASA solar polar probe launched by the Space Shuttle in October 1990. 28 mins

A Collection of "The Movies":

LA, Earth, Mars & Miranda

plus Voyager 2 Neptune Encounter

Created by the Jet Propulsion Laboratory, this video, features four short productions which use satellite/space probe images and super-computer graphic animation. 17.5 mins

An extra feature, 'Voyager 2 Neptune Encounter', illustrates the various aspects of Voyager's encounter with Neptune. 29 mins

Space Shuttle Challenger:

Accident & Investigation

On January 28, 1986, the Space Shuttle Challenger exploded 73 seconds after blast-off from the Kennedy Space Center. All seven crew members died. This video documents task force activities and findings and provides a concise, technical explanation of the cause of the Challenger accident. 29 mins

STS-26: The Return to Flight

This video depicts the highlights of the STS-26 mission, the first launch since the Challenger accident. During the flight, the five-man crew deployed a Tracking and Data Relay Satellite. There is no commentary on STS-26 Highlights, apart from the astronauts' transmissions. The tape is accompanied by a FREE mission guide. 57 mins

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Spaceflight

The International Magazine of Space and Astronautics



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Front Cover: Back from space: orbiter Endeavour on mission STS-68 is seen just prior to touchdown at 1:02 pm EDT (10:02 PDT) on 11 October 1994. Weather conditions at the Kennedy Space Center were unfavourable and the landing went ahead at Edwards Air Force Base in California. NASA



In the Baikonur Museum, Theo Pirard has his finger on the button that fired the Vostok launch vehicle. The museum is mainly dedicated to Yuri Gagarin and chief engineer Sergei Korolev.



Main entrance of Baikonur to the Proton, Soyuz, Zenit and Energiya launch complexes. The construction of the cosmodrome and the associated City of Leninsk (whose name remained secret until the late 80s) began in 1955.

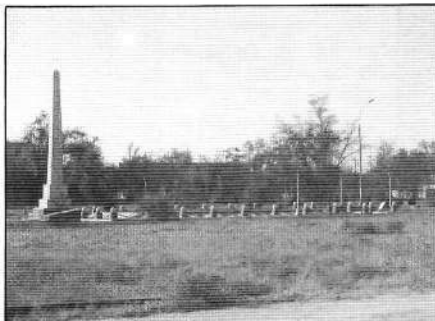
Most Famous Cosmodrome

Baikonur Visit Benefits from Open Policy

An ESA delegation and media representatives recently visited the famous Baikonur cosmodrome on the occasion of the launch of Soyuz TM-20 for the EuroMir 94 mission, just 37 years to the day after the first Sputnik satellite was launched from the same launch pad. The Space Forces of the Russian Ministry of Defence also arranged a very interesting trip to launch and integration facilities scattered over a wide area and *Theo Pirard*, a member of the visiting party, has prepared this special report for *Spaceflight* readers.

The Past

The history of Baikonur is remembered in a museum close to the picturesque houses of Gagarin and Korolev at the Soyuz launch complex. The museum contains the historical command console used for Sputnik and Vostok launches.



On the main avenue of Leninsk, a monument commemorates those who lost their lives in accidents at Baikonur, the largest loss being the accident of Marechal Nedelin.

Also the two main tragedies of the Soviet space programme are described with photos: the accident of Marechal Nedelin on 24 October 1960 when an R16 missile (Cosmos booster) in preparation exploded, killing 57 people and the explosion of an R9 missile that killed another 7 people precisely three years later on 24 October 1963. The 24 October is still considered with some superstition at Baikonur: no launch is made on that date. The names of those who lost their lives in the cause of space exploration are inscribed on a memorial monument in the main avenue of Leninsk.

BY THEO PIRARD

Belgium

The Present

The Baikonur cosmodrome is located in an Asian steppe, 30 km North of the Syr-Darya river and of the specially-built city of Leninsk, which has an airport with connections to Moscow and Alma-Ata. There is some confusion between names as Leninsk (which is also named Tyuratam - the name of the last railway station) is the name of the town. Baikonur, which includes the city, is the name of the space complex. A network of busy railways and bad roads link 9 rocket complexes with 14 launch pads, 35 technical facilities and three propellant fuelling stations. These complexes conduct preparation and launch opera-

The picturesque 'house' of Gagarin is preserved as a memorial. Gagarin and the cosmonauts of the Vostok programme spent the last night before launch inside this small house located within the Soyuz launch complex.



tions for Energiya, Proton, Zenit, Soyuz, Molniya/Vostok, Tsyklon and Rokot boosters. They allow about 40 launches a year to be performed. Approximately 40% of Russian spacecraft launches are conducted from the cosmodrome, including manned, geosynchronous and heavy spacecraft.

The Future

The future of the cosmodrome is now dependent on international cooperation and business operations. This is the reason for the surprisingly open policy practised by the Space Forces of Russian Ministry of Defence, RKA (Russian Space Agency) and RKK (Rocket and Spacecraft Corporation) Energiya. Russian and Kazakh authorities appear to agree about the need to cooperate in order to keep alive this essential infrastructure for the manned missions of Russia in space, for the launches of geosynchronous spacecraft and for business operations in orbit.

The status of Baikonur/Leninsk is still being negotiated between Moscow and Alma-Ata. Russia would like to have a long-term lease agreement but the controversial point that comes up is the amount of the annual charges (\$115 million) to be paid by Moscow to Alma-Ata for the maintenance of the cosmodrome.



The ejection seat used during the Vostok programme on display at the Baikonur museum.



Left: The main square at Leninsk with a statue of Lenin pointing the way to the stars.

Below: The open air market at Leninsk which is crowded from early in the morning until late in the afternoon.

Leninsk

The infrastructure of the Balkonur cosmodrome includes the population of Leninsk, a military city with engineers and technicians of Russian or Ukrainian enterprises and officers and soldiers of the Russian or Kazakh armies. Some 50,000 people (it is not officially confirmed) are still living in apartments under difficult conditions of daily life with problems of water and power, cost of food and materials. There were 70,000 people five years ago with the development of the Energiya/Buran programme.

Launch Complexes

Most Proton payloads are spacecraft for geosynchronous orbit or for the high circular Glonass orbit and are prepared in the same complex North of Leninsk. Close to the Proton complex is the launch area used for Tsyklon. The Proton payloads are launched from two neighbouring complexes, each consisting of two launch pads. Of the four Proton pads only three are in use as a damaged one is being repaired.

There are four other operational launch pads: one for Soyuz and Progress missions (manned programme with the Mir station), one for Vostok/Molniya missions, one for Tsyklon

The Proton integration hall in which up to three Proton vehicles can be prepared simultaneously.



Right: Leninsk consists of many apartment buildings, some of which appear abandoned.

shots and one for Zenith launches. Briefly these are used in the following connections:

Soyuz and Progress spacecraft are prepared and launched from the historical complex with its unique pad, where the first Sputnik and cosmonaut Gagarin were launched.

Launches of Vostok, Resurs and Molniya satellites are made from a separate Soyuz launch complex with one launch pad, which is East of the Soyuz/



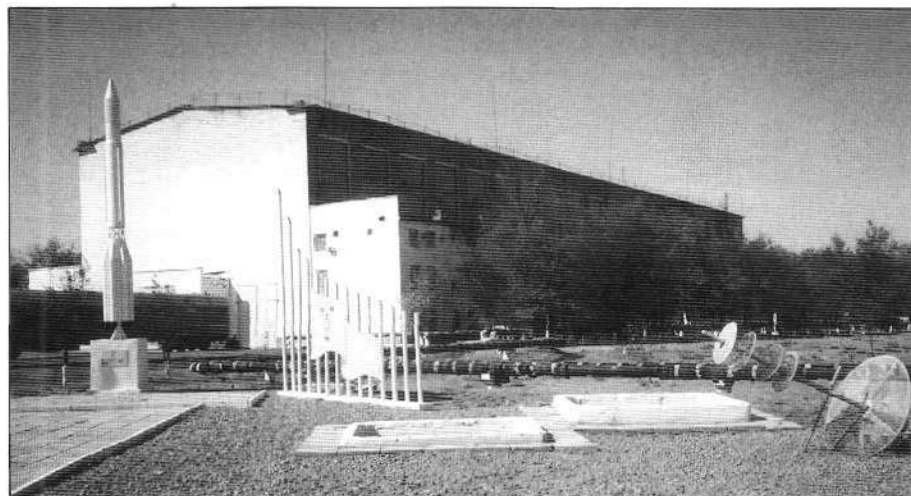
Progress complex and close to the Zenit complex.

Zenit rockets are used to launch Earth observation satellites (Resurs or spy spacecraft) and are prepared in the same facility and launched from two pads, one of which is damaged and under repair.

In addition an ex-missile silo exists for the Rokot (SS-19 missile) launch system, which is to be marketed in association with Daimler-Benz Aerospace Bremen.

People working at the cosmodrome have long train journeys each working day: it takes one hour 30 minutes to go from Leninsk to the Proton complex and one hour 30 minutes to return.

The infrastructure for satellite preparation and launch operations appears to lack clean-room facilities corresponding to Western standards. The Soyuz vehicle is prepared for launch in a very old building with outdated equipment; it is launched from a



pad which appears to be intensively used. The ESA press team saw the first Electro or GOMS (Geosynchronous Observation Meteorological Satellite) which is a big satellite equipped with a great radiometer and optical sensors. Just close to Electro, an Altair data relay satellite was in preparation also under poor conditions. However, many observers, here, admit that Russian-made equipment for space operations is very efficient in orbit.

Electro-1 Schedule

Launch of the Electro-1 geosynchronous meteorological satellite has been awaited since the early 1980s. At the time of Baikonur visit, Electro-1, in spite of its delicate optical payload, was being prepared under very poor conditions in unclear facilities for a forthcoming launch. The first stage of the Proton was in the integration hall at that time. Subsequent to the visit, it was learned that the launch had been delayed because of lack of fuel for the Proton rocket, as the industrial supplier wanted to be paid in advance!

Zenit-2 Launch

At the time of the Baikonur visit a Zenit-2 launch with the Resurs (Resource)-03 remote sensing payload was scheduled for November. The launch vehicle was rather surprisingly stored outside the integration building, in the open air. Subsequent to the visit, it was announced that the launch had taken place on 4 November.

A feature of the payload was the addition of the piggy-back micro-satellite SAFIR-R, which is a project ini-

Below and bottom right: In the satellite preparation hall, the Electro-1 or GOMS-1 (Geosynchronous Meteorological Satellite) was being prepared for a forthcoming launch.



For Theo Pirard, the dream to be at Baikonur on the launch site of Sputnik, Vostok and Soyuz becomes a reality.

ated by the Bremen space technology company OHB-System GmbH.

(SAFIR-R is set to usher in a new era of data communications. In polar orbit at 700 km altitude, its development, production and launch costs are many times lower than for conventional satellites in geosynchronous orbit. Also the much shorter transmission distance makes direct radio contact between satellite and user possible. For SAFIR (Satellite for Information Relay) only a hand-sized transmitter/receiver is needed on the ground for communication between any points of the Earth. SAFIR is also able to transmit position data of vehicles, environmental data of measuring stations or other data with high speed and reliability.

After a period of extensive testing, the satellite is expected to be available for general use in early 1995 and by 1997 there should be a completed network of six satellites in orbit. Operations will be handled by a sister company OHB-Teledata GmbH, which will be one of the

Electro-1 under test.



Progress M25 was stored in the integration hall (MIK) in readiness for launch on 10 November.

first private companies world-wide to offer commercial satellites for data transmission.)

— COSMODROME AND COSMONAUTS

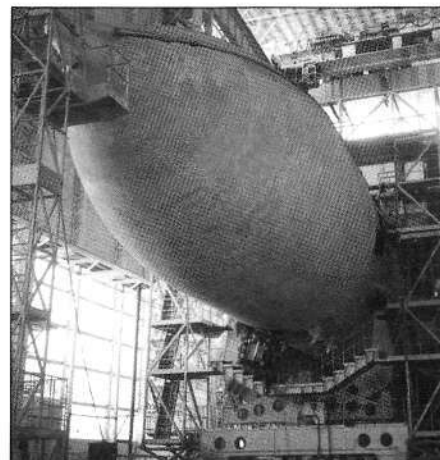
Energiya/Buran Facilities

The former USSR developed an impressive infrastructure at Baikonur to prepare and launch the giant Energiya launch vehicle and the reusable Buran spaceplane. Russia decided to stop financing this expensive programme and consequently all activity has stopped and a strange silence hangs over the facilities.

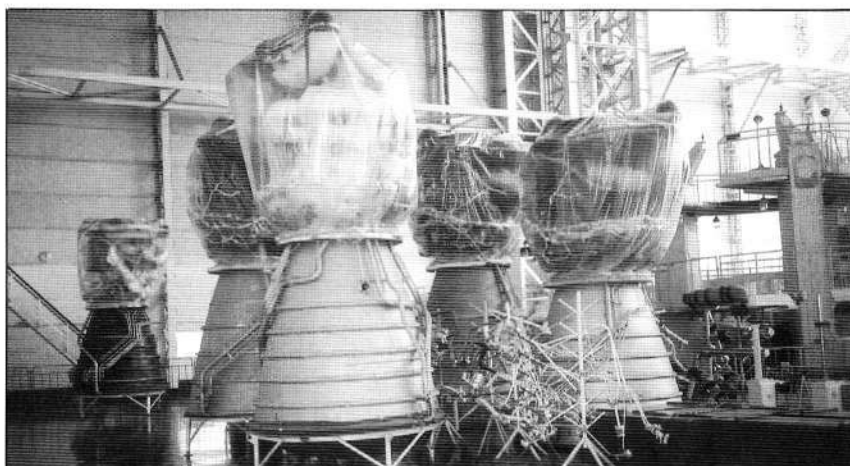
The Energiya/Buran complex is most impressive and its massive white buildings are visible from any launch site of the cosmodrome. It consists of the integration halls for Energiya rockets and Buran planes, test facilities for the Energiya booster and a universal launch complex for Energiya built on the previous location of the lunar N1-L3 complex and consisting of two parallel launch pads for the Energiya-Buran system. One still completely new launch pad has never been used. The other launch pad, for unmanned automated Energiya missions only, was used to test the Buran space plane on 15 November 1988. Another special-purpose launch pad was designed to test and launch the Energiya vehicle when it made its first flight in May 1987. What a waste of money and resources! The RKK Energiya design managers confirmed that these giant facilities are not in use, because no customer has expressed an interest in them and there is no hope that the launch complex will be used again unless the Energiya-M vehicle or some derived

model takes shape, but that will depend on there being a commercial interest for such a launcher in the near future.

The Energiya integration hall looks like a horizontal assembly building with up to four parallel integration bays for the giant Energiya rocket. It is crowded with strap-on boosters, tanks, engines and elements for the development of the powerful launcher, but the technical offices are empty and without maintenance. An engineer of RKK Energiya stated that, "Up to 3,000 technicians and engineers were working until 1989 in this facility. Nowadays, 300 to 400 people are here just for reduced maintenance and current surveillance".



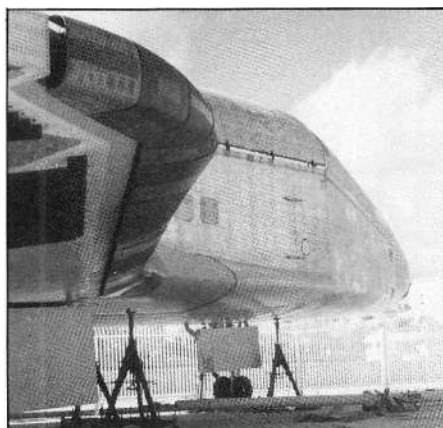
The third Energiya which has been waiting since 1989 to be transported to the launch pad.



Core-stage engines and strap-on boosters in storage in the Energiya integration hall.



The massive white buildings of the Energiya-Buran facilities. Left is the Buran integration hall and, right, the Energiya integration hall.



The third Energiya flight model, which was for a second launch of an unmanned Buran spaceplane in 1989, stands nearby close to the exit of the hall ready for flight but, because of lack of money, it cannot be launched.

The Buran integration hall also gives a dramatic picture of the sudden change in the country's regime. Buran-2 is 30% complete being nearly fully covered by protective tiles and at

Left: The Buran engineering model, exhibited in Gorky Park, is partially covered with thermal protection and equipped with landing gear.

the point of receiving its life support and onboard electronic systems. Buran-1, which flew automatically in November 1988, is stored in a part of the hall but was not visible because of its apparently bad shape. The Buran-3 model is stored at NPO Molniya in Moscow. The structure of an engineering model, with some tiles and landing systems, is exhibited in the Gorki Park of Moscow; it is being converted into an educational facility where young people can pay to use space flight software to simulate a mission on board the space plane.

Acknowledgement

This special report is based on a press trip that ESA organised to the cosmodrome of Baikonur for the Euro-Mir 94 launch. It allowed some 25 representatives of the European press to visit the integration facilities and launch complexes of the most famous cosmodrome. Thanks are due to Franco Bonacina and Daria Robinson, Public Relations of the European Space Agency (ESA), and to Boris Nafikov, Department for External Relations at the Russian Ministry of Defence, Space Forces.

(All photos: Th.P./SIC)

Space Station Cosmonauts

Mir Mission Report: July - October 1994

Russian cosmonauts Viktor Afanasyev and Yuri Usachev returned safely to Earth from the Mir complex on 9 July 1994 in the Soyuz TM-18 spacecraft. This left the space station in the care of three men, Russian Air Force Colonels Yuri Malenchenko, Talgat Musabayev (flying under his Kazakh nationality) and Russian doctor Valeri Polyakov, who had arrived with Afanasyev and Usachev in January and was attempting to set a manned spaceflight endurance record of over 420 days.

The three cosmonauts settled down to a stay expected to end, for Malenchenko and Musabayev, in late October. However, as on recent missions, fate intervened to disturb the regular routine.

Experiments Continue

By the end of July the men had completed extensive photography over Russia and Kazakhstan. Astrophysics work had included observations of stellar sources with the Reontgen telescopes mounted on the Kvant astrophysics module and still more studies of interactions between high-energy charged particles and the Earth's radiation belts using the Maria magnetic spectrometer.

The commander and flight engineer, as was usual, spent time working on preventative maintenance of various systems of the complex and, in particular, the water regeneration system.

The first days of August saw the men conduct X-ray observations of the Hercules X-1 pulsar and other targets and study the flow of charged particles of cosmic origin and their interaction with the Earth's radiation belts.

Geophysical observations included many pictures of the areas around Lake Baikal and adjacent territories. The information, presumably video spectral in nature, was sent to Earth during a TV communications session.

On 18 August the medical experiments continued with Austrian-made equipment to determine the psychophysiological reactions of the cos-

BY NEVILLE KIDGER FBIS

Leeds, UK

monauts while working.

Progress M-24 Drama

On 25 August ITAR-TASS reported that an unmanned cargo spacecraft to be sent to re-supply the three cosmonauts was due for launch. Progress M-24 was scheduled to be launched that evening at 1425 (all times are GMT).

Following Western reports that a cash shortage had forced postponement of a planned July Progress launch, it was revealed that mission planners had scheduled just one Progress M cargo craft to re-supply the Malenchenko crew. Two ships were originally planned but, by omitting the planned third cosmonaut (one Russian report named Gennadi Strelakov) from the Soyuz TM-19 launch on 1 July it was possible to deliver fewer goods to Mir and "save" a Progress carrier rocket.

The new Progress M craft was set to deliver over two tonnes of cargo including 275 kg of equipment for the October ESA mission "EuroMir-94", including a freezer for storing biological samples and a centrifuge, 419 kg of food and water as well as three fur-



The Soyuz TM-20 launch vehicle is lifted into a vertical position on the launch pad by means of an impressive hydraulic system. Th.P./SIC

ther packages of equipment, weighing about 100 kg, for the joint Russian/American mission of March 1995 and a Japanese commercial experiment.

Progress M-24 was duly launched from Baikonur at the specified time by a "Soyuz-5" carrier rocket into a 238 x 192 km orbit, period 88.5 minutes, inclination 51.6 degrees.

Two days later, after being commanded through approach manoeuvres by the staff of the Flight Control Centre at Kaliningrad near Moscow, the unmanned cargo ship caught up with the complex. The FCC staff commanded the start of the automated approach to the Mir base block's front docking port.

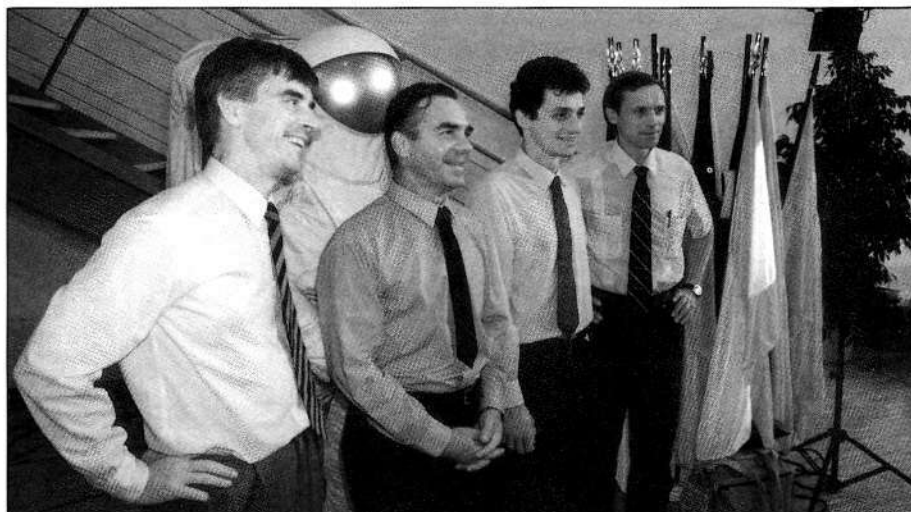
A report said that all was going well at this time. However, at a distance of 10 meters from the complex the unmanned craft's approach and docking system automatically switched off, cancelling the docking for that day. (The approach system was deactivated at a distance of 150 metres according to ITAR-TASS.) Later analysis proved that the fault was in the cargo ship's Kurs system causing a misalignment of the angles which the ship's computer expected to observe.

Nevertheless, there was said to be still enough fuel in the tanks of the Progress craft for at least one further docking attempt.

A special commission was established to study the failure and report back to flight control. Amongst the concerns voiced regarding any failure to dock on the second attempt were worries that the cash advanced to the Russians for the future ESA, USA and

On 14 July 1994, the two EuroMir ESA astronauts made their last appearance in Western Europe before the mission at a press conference at the European Astronauts Centre (EAC) which is located, as an ESA establishment, with the German Aerospace Research Establishment DLR in Cologne. They are seen here with two cosmonaut crew members. From the left are Ulf Merbold, Aleksandr Viktorenko, Pedro Duque and Sergei Avdeyev.

E. RUDOLF VAN BEEST



COSMODROME AND COSMONAUTS

Japanese missions (some \$60 million) might have to be repaid - an unwanted situation for the cash-strapped Russian programme.

To complicate the situation further, the cosmonauts on the station were also running out of food. Initial estimates said that their supply would last to the end of September. Water, being recycled, was less of a priority than the food.

There was also the concern that use of extra fuel on a further successful docking attempt might restrict the ability of the craft to manoeuvre the Mir complex in orbit at a later date.

The 27 August attempt was the third failure to dock at the first attempt by a Progress M cargo ship. Both of the previous wave-offs occurred in 1991 and both were with the Improved Progress M variant following 43 straight successes for the original Progress design. These were :

- Progress M-7. This craft failed to dock due to a failure of the Kurs approach system caused by the dislodgment of the Kvant antenna requiring a replacement mounted during an EVA.
- Progress M-10. This craft's docking was postponed for two days due to software problems.

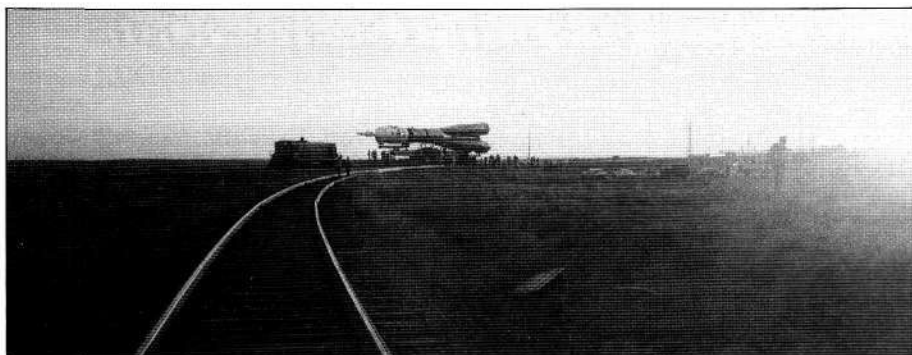
On 29 August it was reported that another attempt to dock was to be made at about 1500 on 30 August, later refined to 1453. The investigating commission decided that because they did not know at that time what had caused the original docking failure, they would command Progress M-24 to dock without using the faulty approach mechanism.

If the cargo ship failed to dock on the second attempt and the fuel was exhausted, extra money would need to be requested to launch a replacement cargo ship. One estimate said that this would require at least 45 days by which time the cosmonauts would have run out of food.

The second attempt to dock with the Mir station on 30 August was a failure.

Controllers had manoeuvred the Progress from 320 km ahead of the station after the first attempt to a position behind it for the new attempt. They had also modified the computer's programming to make the approach angles more conservative in the hope that this would allow more leeway in the approach.

Russian television broadcast live pictures of the cargo ship approaching Mir, then slipping past. The broadcast said that the Progress had bumped into the station four times - al-



With the rising Sun only just above the horizon, the Soyuz TM-20 launch vehicle is hauled by rail to its launch pad in the Kazakh steppe. Th.P./SIC

though other reports stated that no contact had taken place and the nearest approach had been 8 metres. Later that week it was reported that the cosmonauts had listened as the cargo ship made two actual contacts with the docking port during the attempt.

The TV commentary said that a third attempt might be made on 2 September. Although the earlier reports had spoken of the second attempt being the final one, the FCC announced that, a third attempt would be made on 2 September. The investigating commission, chaired by Col-Gen Vladimir Ivanov, commander of the Russian Military Space Forces gave the go-ahead for an untried manoeuvre to be attempted by cosmonaut Yuri Malenchenko.

The plan called for the rendezvous to be made in the automatic mode until the Progress and the Mir complex were separated by one kilometre. From that distance Malenchenko, seated in Soyuz TM-19, was to guide the unmanned craft to a docking. The cosmonaut would use the TV pictures provided by a special camera in the Progress craft which would be relayed to Earth and then back to Mir from the ground. The manoeuvre had been tested on Mir by cosmonaut Gennadi Manakov in March 1993.

Although Malenchenko had not performed the task in space before it was stressed that he had trained for the eventuality in 75 simulations and had passed the tests "with flying colours".

"The prestige of the (space) indus-

try are literally in the hands of one man - Yuri Malenchenko," ITAR-TASS said. The cosmonaut said that he was "ready to fulfil the set task."

Further, the Russians announced that the men's food supply would be exhausted on 15 September. Therefore, the docking attempts would be pursued until the fuel supplies of the cargo ship were exhausted.

On 2 September, therefore, the stakes could hardly have been higher for Malenchenko. The docking attempt was scheduled for 1330 GMT. In a throwback to the old Soviet days the actual manoeuvre, according to press reports, was not shown live on Russian TV.

ITAR-TASS reported, after the event, that a soft-dock had been achieved shortly after 1340, as the cargo ship and the manned complex passed over the Atlantic ocean.

Vsevolod Latyshev, an FCC spokesman, said later that the difficult manoeuvre had been accomplished "at the first attempt and everything went smoothly." He continued by saying that the tension had finally lifted from the situation.

Back to Normality

On 5 September, just hours after the docking the cosmonauts began a biotechnology experiment to grow monocrytals of vegetable proteins with samples delivered by the Progress craft.

ITAR-TASS revealed that an Extravehicular Activity had been scheduled for 9 September which would be undertaken by Malenchenko and Musabayev, the main task being to examine the front docking port to look for evidence of damage by the two collisions with Progress M-24.

In addition Musabayev was to conduct "scheduled repairs" of the thermal-insulation cover of the Kristall module in the area where the collision with the manned Soyuz TM-17 craft took place in January.

A decision had yet to be taken on a further EVA,

The ESA logo is seen on the fairing of the TM-20 launch vehicle as it rests on its rail transporter. Th.P./SIC



scheduled for 13 September, that would enable any repair activity required to the docking port to be undertaken.

EVA of 9 September

On 8 September ITAR-TASS reported that Malenchenko and Musabayev would begin their EVA the next day at 0640. They were expected to stay outside for 3 hours and 40 minutes repairing the exterior surface of the station and placing new equipment.

The cosmonauts were then to prepare the site for the installation of a new crane jib to help manoeuvre into position various pieces of future cargo (such as the Kristall module's re-usable solar power arrays which are to be mounted on the Kvant astrophysics module).

The second part of the EVA would see Musabayev move down to the area just below the docking port of the Kristall module to "patch-up" the screen-vacuum thermal insulation in the area where the Soyuz TM-17 ship gently collided with the module in January during a fly-around to photograph the module's docking mechanism in preparation for the scheduled dockings with the American space shuttle orbiter "Atlantis" beginning in June 1995.

They would then inspect the docking port.

Malenchenko and Musabayev began their EVA on schedule and were expected to end it at 1026. The excursion was monitored closely by the FCC staff led by former cosmonaut Vladimir Solovyov. Dr Polyakov monitored the health of the two space walking cosmonauts on equipment inside the complex.

The EVA took almost 90 minutes longer than planned and ended after 5 hours and 4 minutes. The Russians noted that the cosmonauts' Orlan-D EVA suits had a time limit of 6 hours and said that Russian and American specialists were working on "tactical-

technical requirements" for a common space suit for use with the International Space Station.

The inspection of the docking port revealed only minor scratches which required no further attention, ITAR-TASS said.

EVA-2

Tuesday 13 September saw the cosmonauts' second EVA of the mission. The tasks were described as clearing the path for the expected arrivals of two scientific modules over the next year (Priroda and Spektr) and also making preparations for the 1995 docking of the US space shuttle orbiter Atlantis.

Malenchenko and Musabayev exited the Kvant-2 airlock at 0631 for an anticipated 4 hour period of work out-



Yelena Kondakova

ESA

(Supplied courtesy Peter Smolders.)

side the complex, according to ITAR-TASS.

One of the first operations, in preparation for the removal of the Kristall re-usable solar arrays, was the checking



Soyuz TM-20 being prepared for its mission. Th.P./SIC

of various joints and electrical cable links, as well as the state of the solar panels themselves.

The two cosmonauts used the complex's boom to move over to the Kvant astrophysics module and checked the mounting brackets and drives for the solar panels which had been mounted by an earlier expedition.

The repositioning of the solar panels will give greater clearance for Atlantis dockings although earlier Soviet plans had called for the docking of the now-abandoned Buran orbiter with the Kristall module.

The men also checked the state of the foundations of the 14-meter-tall Sofora girder upon which is mounted the VDU manoeuvring block. They also dismantled various containers which had been mounted on the smaller Rapana girder, also located on the Kvant module, one year earlier.

The men also mounted another amateur radio communications antenna to the exterior of the station for use with the on-board ham radio shack. The VHF antenna will provide opportunities for any licenced ham operator to contact the Mir station to continue the station's long association with this hobby. Polyakov checked out the system shortly after the antenna was erected.

The cosmonauts returned to the Kvant-2 airlock and sealed themselves in at 1232, six hours and one minute after the start of the EVA.

EuroMir Crew

The crew for the next Mir occupation was introduced to the press on 14 September. The main crew consisted of Russians Aleksandr Viktorenko and Yelena Kondakova and German Ulf Merbold, flying on the EuroMir mission on behalf of the European Space Agency.

Whilst Viktorenko would be making his fourth visit to the Mir station, and

Presentation of the prime and backup crews for the Soyuz TM-20/EuroMir 94 mission. Th.P./SIC





ESA astronaut Ulf Merbold (left) and Russian cosmonauts Aleksandr Viktorenko and Yelena Kondakova report their readiness to General Vladimir Ivanov, chairman of the State Commission before boarding the bus and leaving for the launch pad. Only Viktorenko wears his headset.

PETER SMOLDERS

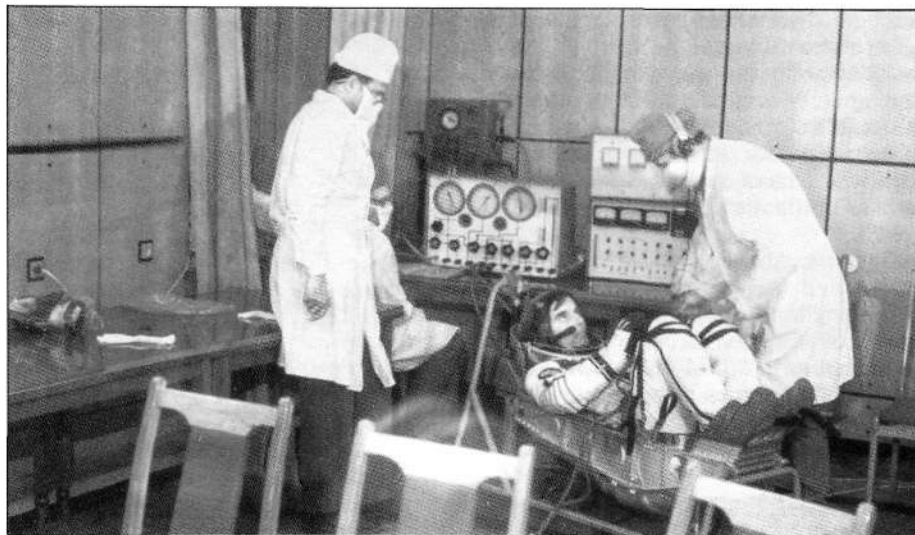
Merbold would become only the second person to fly both American and Russian launchers (Sergei Krikalev being the first), the attention of the popular press was focused upon Kondakova.

The 37-year-old flight engineer was to become only the third Soviet/Russian female cosmonaut and was scheduled to fly the longest ever mission by a female. The current record was set in July by Japanese cardiologist astronaut Mukai on the shuttle Columbia. But her record of 14 days would easily be eclipsed by Kondakova's projected 174 day mission.

The launch of Soyuz TM-20 was originally set for 3 October but was rescheduled for the next day on account of ballistics considerations.

The TM-20 and TM-19 crews were to work jointly aboard the station for 30 days before Malenchenko, Musabayev and Merbold returned to Earth

NASA astronaut Norman Thagard comments on the launch of Soyuz TM-20. He is currently in training to fly with the next Soyuz TM-21 spacecraft. Th.P./SIC



In the cleanroom of Baikonur, Ulf Merbold is undergoing a test of his space suit a few hours before launch.

P. AVENTURIER FOR ESA (Supplied courtesy Rolf H. Schoevaart.)

leaving Viktorenko, Kondakova and Dr Polyakov aboard the station.

The landing of the latter trio was moved from 9 March, 1995 to 26 March, 1995 to allow for a daylight recovery. The earlier date meant bringing the Soyuz down during darkness with the resultant search-and-rescue operation possibly posing difficulties. The concern was evidently to make sure that Dr. Polyakov was recovered swiftly for immediate medical evaluation of his condition.

Kondakova, a Moscovite, is married to veteran cosmonaut Valeri Ryumin who once forbade other Russian female cosmonauts from flying in space. Kondakova, an employee of the NPO Energiya firm was selected as a cosmonaut in 1989 and qualified for the flight into space through the ranks. Ryumin, according to Kondakova did not approve of her mission but "had to resign himself to my plans".

She revealed that the NPO Energiya organisation had received just 25% of

the fixed financing funds promised for the year, calling such events, "continuous surprises".

Kondakova said that she had found slightly less time to prepare for the flight than her male colleagues due to her parental duties looking after her eight-year old daughter.

Kondakova said that she had to travel the 50 km from Moscow to Star Town every day for training and still pick up her daughter from school back in Moscow and prepare dinner for her husband who is based at the NPO Energiya offices.

Kondakova's daughter thinks that her mother is going on a business trip and is expecting presents upon her return.

EuroMir 94

The six cosmonauts who had been in training for the Russia/ESA mission flew to the Baikonur Cosmodrome on

28 September in two aeroplanes to undertake their last preparations. The prime crew of Viktorenko, Kondakova and Merbold travelled in one and the reserve crew of Yuri Gidzenko, Sergei Avdeyev and Pedro Duque were in the second.

At the cosmodrome the two crews underwent final medical checks and carried out physical exercises, yet another docking simulation, an examination of their Soyuz TM-20 craft and were fitted for their launch and reentry Sokol pressure suits.

In accordance with the traditions of the past the actual flight crew was officially selected by the State Commission the day prior to launch.

On 3 October, early on 4 October Baikonur time, the Soyuz TM-20 craft was launched with the three-person crew to begin the EuroMir mission. ■

(Mir Mission Report continues with details of the EuroMir 94 mission in a forthcoming issue.)



EUROMIR 94 in Pictures

BY ROLF SCHOEVAART
The Netherlands

On 4 November 1994 the longest mission in European space history, EuroMir 94, came to an end with the successful landing of ESA astronaut Ulf Merbold aboard the Soyuz TM-19 spacecraft in Kazakhstan. A month before he had been launched aboard Soyuz TM-20 and arrived at the Mir space station two days later.

The experiments on Merbold's flight will provide European scientists with important data on the effects of weightlessness on the human body. During the mission Merbold took numerous biological samples of blood, saliva and urine. He also conducted technological experiments and took many photographs of the Earth's surface.

EuroMir 94 was the first of two ESA

missions to Mir in order to prepare for long-duration flights to the International Space Station. ■



Above: On 19 October, 45 school children from all ESA's thirteen Member States were attending the "Classroom in Space" event at ESTEC Visitors' Centre at Noordwijk Space Expo in the Netherlands. A live ground-to-space link was set up with Ulf Merbold and the pupils were able to talk to Merbold and ask questions about the space experiments and the working and living conditions inside Mir. In this picture ESA astronaut Dr Wubbo Ockels, who was interpreter and intermediary during the "space class", is giving a lecture about space experiments as an introduction to the live event.

ESA/ESTEC



Left: Prime and backup crews for EuroMir 94 pose together on launch day in Leninsk. From left to right the first crew: Aleksandr Viktorenko, Yelena Kondakova and Ulf Merbold; and the second crew: commander Yuri Gidzenko, flight engineer Sergei Avdeyev and ESA astronaut Pedro Duque.

P. AVENTURIER for ESA

Left: The successful launch of Soyuz TM-20 on 4 October 1994, 03h42 (Baikonur Time). Ulf Merbold is the first West European to have been launched on the US Space Shuttle and on the Russian Soyuz Rocket.

ESA

Below: Ulf Merbold, Yelena Kondakova and Aleksandr Viktorenko waving goodbye on the steps up to the gantry on the launch pad.

P. AVENTURIER for ESA





The presentation to Helen Sharman by Mr G. Fisher, Managing Director of Robinson Brothers Ltd.

Helen Sharman at Open Day *Popular Enthusiasm for Space Development*

This year the Company for which I work, Robinson Brothers Ltd of West Bromwich, celebrated their 125th anniversary. To mark the occasion, they decided to hold an Open Day. The Company is a large independent chemical manufacturer and therefore sought someone connected with the chemical industry as a guest of honour. Who better than one of Britain's most famous chemists - Helen Sharman. Perhaps slightly better known as the UK's first astronaut. Happily, she agreed to attend the event on 17 September 1994 and also give a series of talks to the General Public.

Helen agreed to give four separate talks, each lasting half an hour and said that if there was sufficient demand, she would give a fifth. To put it mildly, there was more than enough demand! Each session was a completely full house of eighty people.

Enthusiasm was very high amongst those who attended and before each talk they keenly examined the display of posters and copies of Helen's book "Seize the Moment".

The talk began with a slide show, the first slide showing the Mir complex was accompanied by a brief description of the exhilaration of a launch, the three and a half Gs of acceleration, and a simple science lesson explaining why a spaceship stays in orbit.

She then described, with accompanying slides the experiments she conducted for the Juno mission. These particularly concerned the growing of seeds and protein crystals. An example of the advantage of the lack of gravity was provided by the theoretical production of an alloy of lead and aluminium. On Earth, you can melt the two together, but as they cool the lead sinks and the aluminium rises. In space however, with a lack of gravity, the mixture stays homogeneous as it cools.

The slide show then moved on to how a human being is kept alive in space by, firstly, providing a breathable atmosphere on-board the space station. This was accompanied by a slide of

BY PETER GREGORY FBIS
West Midlands, UK

one of the lithium hydroxide canisters and also some interesting thoughts concerning the lack of convection in space. She pointed out that it is not sufficient to provide oxygen in the station atmosphere, it must be continually stirred up. This is because, in a still atmosphere with no convection, astronauts could easily suffocate on their own breath. The exhaled carbon dioxide would just stay around their heads and be inhaled again, therefore fans are required to circulate the air and prevent this.

The talk turned to the subject of space food, with a slide of various types of Russian space food, including dried cabbage! I was amused by her

description of the feeling after you had eaten in space, she likened it to drinking a pint of orange juice and then going for a run!

The old chestnut about the space 'toilet' was dealt with using a slide of the toilet aboard Mir and a short explanation as to how one used it. Another insight into life aboard Mir was the fact that even urine was processed back into drinking water, however they had just taken 60 litres of fresh drinking water to Mir so this was no problem! She also said that some of this water was electrolysed and the oxygen stored while the hydrogen was vented overboard.

There then followed a slide of her bedroom aboard Mir, particular attention being paid to the window. As with all astronauts, she was mesmerised by the view of the Earth. She admitted that before launch, of all the aspects of the mission she had considered, the view outside was not one that she had really thought about. On one of the Earth view slides it was possible to discern a cross-roads in the desert. She said that it is easy to spot roads like this because one's eye is drawn to these long, straight lines as they look so unnatural.

There was a view of sunrise and it was explained that astronauts see this view sixteen times a day.

The final slide was of the capsule after landing. Helen explained that during re-entry she had experienced four and a half Gs and that through a small window next to her she could actually see the outside of the capsule melting! She quickly added that it was designed to do this. There was a short lesson on how the ablative shield on the capsule works and why there was charring visible on the capsule in the slide.

After the slide presentation Helen produced some of the items that she was allowed to keep after the mission. She did the presentation wearing the grey jump suit that she had worn during simulator training and also showed us the suit that she had worn whilst on Mir. Unfortunately, her spacesuit had recently been sold at Sotheby's in New York for \$50,000. One of the items that she had was a tube of fruit juice and she

Meeting Britain's First Astronaut, Helen Sharman OBE

Among those attending the Open Day was Haroon Qureshi who sends this photo and writes:

Helen gave a riveting account of her eight day mission aboard the Mir space station in May 1991. She used slides to depict activities she and her Russian colleagues undertook.

Afterwards, I asked Helen whether Michael Foale (the British-born NASA astronaut) congratulated her following the Juno mission. She said Michael did, remarking: "He's really a nice fellow".

Haroon Qureshi and Helen Sharman.



demonstrated the cunningly attached top which, when unscrewed, dangled on a piece of string!

We then saw some of the wet-wipe type cloths that were used for cleaning skin and hair and also the cloths that were used to dry up with afterwards. She said that although there was a shower on board the station, it took eight hours to use it!

Other items were the utensils she had used for eating food and the standard toothbrush for use afterwards. The only difference from use on Earth was that the toothpaste did not foam and was swallowed afterwards.

One final note was that if you wish to trim your nails on Mir, since the Russians do not have nail clippers and scissors are officially prohibited, you have to use a nail file and stand with your hands next to a vacuum cleaner. Similarly, if you want a haircut, your crew mate does it for you while you sit with a vacuum cleaner poised above your head!

There followed a lively question and answer session, which also raised some very interesting points. She revealed that the cosmonauts, who returned with her and had been in space for six months, took three days before they could walk in a straight line and a month before they were back in full training. Also, in training, she had been taken to eight Gs in a centrifuge, even though the maximum she was expected to experience during the mission was four and a half.

Finally, cosmonauts have their heartbeat monitored every time they are in the Soyuz capsule. During the docking problem they had, which required the Commander to take manual control, her heartbeat had gone from 56 beats per minute to 120+, although she was not aware of it at the time.

At the end of each session, Helen kindly took part in a book signing session with various autographs and photographs thrown in.

At the end of the day Robinson Brothers Ltd presented Miss Sharman with a crystal bowl to mark her presence at what was a most enjoyable and interesting day.

Last but not least, I would like to make some comments about the people that attended these sessions. For me, one of the most interesting parts of the whole day concerned the comments of the people as they left. In all, some four hundred members of the General Public listened to the talks and this constitutes a good sample for an 'exit' poll. There were a few space 'buffs' there, but the vast majority were a good cross-section of the General Public. They were very consistent in wondering why Britain was not taking a stronger hand in the space business. Why was Britain not having greater involvement with the ESA programmes? There was a strong feeling

that here was another area of technology in which Britain was about to be left behind.

I think I had started to become brain-washed by the propaganda myself, thinking that people are bored with space and have no interest in it. This event proved to me beyond doubt that the General Public are hungry for information on space and as for them being bored with space, nothing could be further from the truth.

Photos: D. SIMKIN for ROBINSON BROTHERS LTD



Helen Sharman admires the crystal bowl presented to her.

Afghan Cosmonaut in Germany

Abdul Ahad Mohmand Interview

On a recent visit to Germany Neil Da Costa had the opportunity to interview Colonel Abdul Ahad Mohmand, Afghanistan's first cosmonaut. Launched aboard Soyuz TM-6 in August 1988 he spent eight days aboard Mir. He was launched with Colonel Vladimir Lyakhov and Dr Valeri Polyakov, who is currently on board Mir attempting to set a new space endurance record of 18 months. The back-up crew were Mohammed Dauran, Anatoli Berezovoy and Gherman Arzamazov. Mohmand was the fastest trained cosmonaut ever taking only six months from arriving at Star City to being launched. He had the advantage of being an air force pilot fluent in Russian.

Mohmand and Lyakhov endured a dramatic re-entry when sensors aboard their Soyuz spacecraft became misaligned leading to three attempts before a safe return.

Why did you leave Afghanistan?

I could not stay because of the civil war. I am from the Pashtun tribe which is now fighting against the Mujahaddin who have formed an alliance with the Tajik's. Not being a Tajik I had to leave.

What happened to your back-up Mohammed Dauran?

He is of the Tajik tribe and is still there working for the Military Air Defence under the new President. He lives in a UN safe area.

Can you tell me the names of any of the other final six cosmonaut candidates from Afghanistan sent for evaluation to Moscow?

There was Colonel Akar Jan, Major Shere Zamin and Mohammed Jahid a civil airline pilot.

Was your training for a spaceflight in six months very intense?

It was not really intense, only a little. Since we already were fluent in Russian this was not so difficult.

Did you train with any other cosmonauts apart from those already known?

We only trained with these two crews and no-one else.

Did your training overlap with any other crews?

Yes, with the French crew of Chretien and Tognini (Soyuz TM-7) and before us

Neil Da Costa (left) and Colonel Mohmand.



were the Bulgarian crew of Alexandrov and Stoyanov (Soyuz TM-5).

Was Dauran's appendicitis the reason why you flew on Soyuz TM-6?

No, even before he suffered from appendicitis I had already been chosen as the first Afghan to fly into space. Dauran had an additional intestinal problem. Also I was younger and fitter.

What items did you take with you into space in your personal luggage?

I took two copies of the Koran, one for the Star City museum and one for myself which would go to a museum in Afghanistan. I also took the national flag and a packet of envelopes for franking aboard Mir.

Tell me about the difficult re-entry that you and your Commander Vladimir Lyakhov endured.

Amongst the many lights of the Soyuz spacecraft systems I spotted an alarm signal and warned my Commander at once that he should deal with it. He should have put the matter right and then contacted Ground Control (Kaliningrad) to say that everything would be okay but Ground Control were worried. When we landed an engineer came to me and told me that there were only 20 seconds left before the re-entry engines would have run out of fuel!

After the mission did you keep your spacecraft?

No it went to a museum in Afghanistan but I think that the invading army took over the museum and probably sold it.

Do you think that you will be able to return to Afghanistan in the near future?

At the moment all communications with Afghanistan are severed. No post, no telecommunications, no flights. It will not be possible in the near future.

Acknowledgement is due to Claudia Kaiser for help with the interpreting from German.

DR NEIL DA COSTA

New Russian Metsat Launched

The Russians have finally launched their contribution to the world network of geostationary meteorological satellites - the Elektro. It joins satellites launched by America, Europe, India and Japan for a world-wide system of weather observations. (See also p.5 and p.21).

The tri-axis stabilised Elektro satellite was launched from the Baikonur cosmodrome in Kazakhstan on 31 October at 1430:55 GMT by a Proton booster. Earlier reports had claimed that the planned 26 October launch had been delayed because the enterprise which supplies the fuel for the Proton booster had refused to deliver their goods until it had received an advance cash payment. The payment was reportedly made before the fuel was despatched.

The Elektro satellite is to be positioned at 76 degrees East and carries TV and radiometric instruments operating in the visible and infrared bands with resolutions of 1.25 and 6.5 km respectively. The planned operational life is three years minimum. The development of the Elektro satellite began over 15 years ago and was continuously delayed due to cash shortages. In addition there were problems in the development of software for two on-board computers. Leading data on Elektro are: height 6 m; diameter

1.4 m; width across solar arrays 12 m; weight 2,580 kg; payload 900 kg; orbit geostationary.

At a press briefing prior to the launch the Chairman of the Economic Satellites Commission Viktor Kozlov emphasised that Russia was to continue the active use of satellites to benefit the economy. He said that an oceanographic satellite Okean had been orbited from the Plesetsk Cosmodrome in northern Russia on 11 October by means of a Tsyklon carrier rocket. Major applications of these types of satellites are the provision of accurate information on ice conditions in the Arctic, Antarctic and northern seas. They provide ships with information to navigate these waters safely using optical, microwave and radiolocation transmissions.

Another Resource-1 satellite, providing images of the surface of the Earth was launched on 4 November by means of a Zenit-2 carrier rocket from Baikonur.

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SPACELINE

THE LATEST NEWS FROM SPACE

Crew Assignments for Shuttle-Mir Docking Missions

First Docking Mission: STS-71

On 3 June 1994, NASA announced the selection of the STS-71 crew which will be launched on 24 May 1995 using the orbiter Atlantis to perform a docking with the Russian Space Station Mir to exchange crews. The mission will be led by the then Chief of the Astronaut Office, veteran astronaut **Robert L. Gibson** (STS-41-B, STS-61-C, STS-27, STS-47). Joining him will be Pilot **Charles J. Precourt** (STS-55) and Mission Specialists **Ellen S. Baker** (STS-34, STS-50), **Gregory J. Harbaugh** (STS-39, STS-54) and **Bonnie J. Dunbar** (STS-61-A, STS-32, STS-50 and training as backup crew member to Norman Thagard for the Mir-18 mission in Star City, Russia since February 1994). Passengers are Russian cosmonauts **Anatoli Y. Solovyov** and **Nikolai M. Budarin**.

STS-71 is the first of seven to ten Space Shuttle missions to Mir during the 1995-1997 timeframe. These missions are planned under a cooperative agreement between NASA and RSA under the protocol to the Human Space Flight Agreement which was signed in December 1993.

Besides the five American astronauts and the two Russian cosmonauts, STS-71 will carry a docking system compatible with the Russian Mir space station (the so-called APDA, Androgynous Peripheral Docking Assembly, originally developed for Buran-Mir missions), approximately 1100 pounds of equipment for use on Mir and a Spacelab module in the payload bay in which various life sciences experiments and data collection will take place throughout the 10-day mission. Two days into its flight the Shuttle will dock with Mir, where the Mir-

18 crew of two cosmonauts (**Vladimir N. Dezhurov** and **Gennadi M. Strekalov**) and NASA astronaut **Norman E. Thagard** (STS-7, STS-51-B, STS-30, STS-42) will have been aboard for 90 days, following an earlier launch in a Russian Soyuz TM capsule. The STS-71 and Mir crews will conduct five days of joint medical research on the physiological effects of extended space flight. The Mir-18 crew, including Thagard, will join the STS-71 astronauts for the trip back to Earth, while the two new cosmonauts (Solovyov and Budarin, the Mir-19 crew) will remain aboard the Russian space station for a long duration flight.

Second Docking Mission: STS-74

On 2 September 1994, NASA announced that the second Space Shuttle mission to rendezvous and dock with the Russian Space Station Mir, (STS-74, scheduled for the fourth week in October 1995) will be commanded by **Kenneth D. Cameron** (STS-37, STS-56). Joining him are Pilot **James D. Haise Jr** (STS-85) and Mission Specialists **Jerry L. Ross** (STS-61-B, STS-27, STS-37, STS-55), **William S. McArthur Jr** (STS-58) and Canadian **Chris A. Hadfield**.

The primary objective of this six-day mission is to attach a permanent Russian docking module to an orbiter docking system using the Shuttle's robot arm, before placing the docking module on to the Mir space station, where it will remain for use during all future joint US-Russian Mir docking missions. Throughout the flight various life sciences investigations will be performed.

Before his new assignment Cameron managed NASA operational activities at Star City and at the Russian mission

control centre at Kaliningrad, since February 1994. His responsibilities included supervising NASA astronaut training at Star City. He also participated in personnel training to acquaint American astronauts with the operational aspects of Russian vehicles and training facilities.

Third Docking Mission: STS-76

Veteran astronauts **John E. Blaha** (STS-29, STS-33, STS-43, STS-58) and **Shannon W. Lucid** (STS-51-G, STS-34, STS-43, STS-58) will report to Star City in February 1995 to begin training for a four-month stay aboard the Mir space station. One of them will be launched to Mir aboard STS-76 in March 1996, while the other will be the backup. This will be the third Shuttle-Mir docking mission and will be commanded by astronaut **Kevin P. Chilton** (STS-49, STS-59). Two-person teams to succeed Blaha and Lucid will arrive in Russia in April and October 1995 to train for the next scheduled long-duration stays aboard Mir.

Further Docking Missions

In August 1994, NASA astronaut **William F. Readdy** (STS-42, STS-51) replaced Kenneth Cameron as NASA manager at Star City. Readdy will command the fourth Shuttle-Mir docking flight (STS-79), in July 1996.

On 1 November 1994, astronaut **Ronald M. Sega** replaced Readdy as the NASA manager of operational activities at Star City. Sega flew on the first joint US/Russian Space Shuttle mission STS-60, together with Russian cosmonaut Sergei K. Krikalev and other American crewmembers. This and his new assignment makes him eligible to command either the fifth, the sixth or the seventh Shuttle-Mir docking flight.

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Launch Failure for Arianespace

A third-stage malfunction led to the loss of Flight 70 launched from Kourou at 10:55:51 GMT on 2 December 1994. The Ariane 42P vehicle performed normally during first and second-stage burning. The third stage ignited but failed to function at full thrust and orbital velocity was not attained.

The vehicle's payload was PanAmSat 3, the second of the PanAmSat new generation satellites built by Hughes Space & Communications for the US company PANAMSAT LP (USA) and having a liftoff mass of 2985 kg. It was intended to be located at 43°W and provide telecommunications and TV programmes over the Atlantic zone.

Analysis of telemetry records is underway with particular attention on the cryogenic third stage, H10 III, which was in use for the first time, being derived from its previous version, H10 plus, for improved performance. This new development was decided in January 1993 with the agreement of ESA and CNES and passed its qualification phase in August 1994.

Third-stage propulsion was redesigned with:

- A better structural ratio obtained by a reduction of dead space. The propellants, which are increased by more than 700 kg, are enclosed into a structure whose mass is slightly reduced, and the position of the tank bottoms was optimised.
- Increments of thrust, mixture ratio and combustion duration, while keeping within the required qualification margins.
- Better consumption of hydrogen at the end of the flight.
- Better use of the helium pressurisation which enables, thanks to a more efficient heat exchanger, the propulsion duration to increase by 30 s.

First analysis has shown that after normal ignition of the third stage, the gas generator injection valves opened but pressure in the gas generator was low, resulting in an engine performance which stabilised at about 70% of its nominal steady state value. This thrust was not sufficient to complete the mission after a total flight time of the third stage of 740 s. A technical inquiry board is to be appointed.

Status Upgrade for Plesetsk

On 14 November by Presidential Decree, Plesetsk was promoted to be the First State Cosmodrome of the Russian Defence Ministry. Plesetsk has had no official status as a cosmodrome until now.

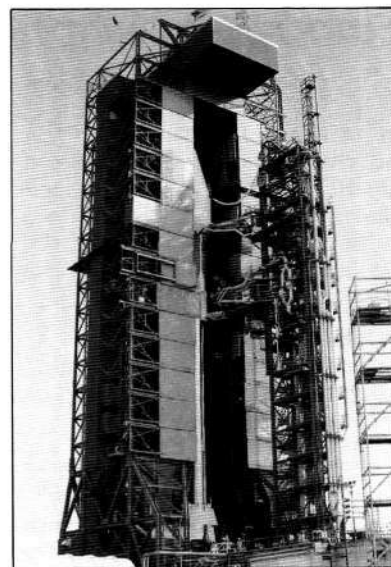
The Russian Space Forces are organising the transfer of spacecraft launchings from Baikonur to Russia in support of Russia's independent space policy.

Successful Launch for Orion 1

On 29 November 1994, the communications satellite, Orion 1, designed and built by Matra Marconi Space, was launched into space on an Atlas IIA rocket from Complex 36 Pad A at Cape Canaveral.

The satellite, whose launch mass was 2361 kg, is currently being manoeuvred from its initial super-synchronous orbit above the Earth towards its geosynchronous orbit which should be attained by 10 December 1994.

A team in a newly commissioned Spacecraft Control Centre at the Stevenage, UK facility of Matra Marconi Space will control and guide the satellite into its final orbit, carry out in-orbit tests and then hand over the satellite to the customer by the end of January 1995 when it will go into operation for the start of its 12-year design lifetime. Orion 1 will be owned and operated by the Orion Atlantic Partnership, a consortium of major international corporations and will provide business television, data transfer and electronic news gathering for the USA and Europe.



Atlas IIA (#110) carrying the Orion 1 payload still sits on the launch pad a few hours after its scheduled launch on 22 November 1994. The countdown stopped at T-4 s when the ground launch sequencer determined that the interstage umbilical did not disconnect. The engines were not started. PETER GUALTIERI, W. KENTUCKY NEWS



The Spacecraft Support area at Matra Marconi Space's Spacecraft Control Facility at Stevenage, where the condition of the satellite and its systems is monitored by live telemetry from the satellite. MMS

Fishing Vessels in Satellite Trials

Nine-month long trials of a satellite-based tracking system for monitoring the position of fishing vessels became operational last October and involve some 20 volunteer fishing vessels from the UK which will be fitted with Global Positioning System receivers and Data Transmission systems enabling automatic data transfer to Central Tracking and Monitoring Stations in London and Edinburgh via satellite.

The UK trials are part of a set of parallel trials being undertaken by EU member states, as required by Article 3 of the EC Fisheries Control Regulation, Council Regulation (EEC) 2847/93, which came into operation on 1 January 1994. The purpose of the trials is to evaluate the use of electronic tracking systems for monitoring the movements of fishing vessels.

The Council of European Ministers is required to decide before 1 January 1996 if, to what extent, and when a continuous position monitoring system, either land or

satellite-based, should be installed on the Community's fishing fleet. In reaching its decision the Council will take into consideration the results of the pilot projects being carried out by all the Member States.

Smith System Engineering of Guildford, Surrey, supported by Peter Derham Associates has been appointed by the UK Fisheries Departments to act as prime contractor and is responsible for design, integration and commissioning of the tracking system and for assisting with the trials design and evaluation of results. Peter Derham Associates will provide technical expertise in fisheries management and monitoring, control and surveillance and will support Smith in management and planning of the trials.

Four satellite position monitoring terminals from four different suppliers will be involved, two using Inmarsat satellite communications, one using Eutelsat and one using Argos.

—European Rendezvous

European Astronaut on STS-66 Mission

ESA Telescience Operations at Brussels

On 14 November European Space Agency astronaut Jean-Francois Clervoy and five NASA astronauts returned to Earth aboard the Space Shuttle Atlantis after the highly successful 11-day STS-66 mission of atmospheric research. The Shuttle glided to a perfect landing at Edwards Air Force Base, California, touching down at 16h 33 Central European Time (CET), after bad weather diverted the Shuttle from a planned landing at the Kennedy Space Center, Florida.

The mission was in support of the Mission to Planet Earth programme and the furtherance of international cooperation. (*Spaceflight*, September 1994, p.316). European experiments formed an important part of the ATLAS atmospheric laboratory. The Belgian-led SOLCON and French-led SOLSPEC experiments both gathered data on the Sun's energy and its variations and their instruments were mainly operated remotely from the Belgian Space Remote Operations Centre (BSROC) in Brussels using a telescience system set up by ESA.

The SOLCON instrument worked perfectly during the mission and SOLSPEC readings appeared extremely accurate and comparable with those of other instruments flown aboard Atlantis that operated at the same wavelengths. The data will be used to detect trends in the Sun's energy output that affect the Earth's atmosphere and climate.

During the flight Clervoy participated in interviews with European television and press reporters in the US and Paris, France. He was very

struck by the beauty of the Earth and said in an interview: "It's indescribable. It's so beautiful, really magnificent. You could call it the blue beauty. You never get tired of the sunrises and sunsets".

Jean-Francois Clervoy played an important role in the mission, using the Shuttle's robot arm to deploy a German atmospheric research satellite, called CRISTA-SPAS, and conducting other experiments within the Shuttle's cabin. The CRISTA-SPAS satellite was retrieved by the Shuttle's robot arm as planned on 12 November. The Shuttle rendezvoused with the spacecraft using the new approach to be used for the forthcoming Shuttle-Mir docking mission.

The link-up of the shuttle with Mir next year is of particular significance to ESA because the Shuttle will return with materials science samples from the recently completed EuroMir 94 mission.

Clervoy also tested a special seat that will be used next year when Atlantis docks with the Russian Mir space station. In this seat astronauts and

cosmonauts will be able to return to Earth in a reclining position after long-duration Mir flights.

Clervoy is the second ESA astronaut to fly in space as a Shuttle mission specialist. Claude Nicollier was the first, and Maurizio Cheli has completed training at NASA's Johnson Space Center as a mission specialist and is awaiting his first flight.

Telescience Planned for Space Station

Telescience is an area in which ESA is keen to support science by providing a direct service to scientists. This was achieved on ATLAS 3 through the Belgian Space Remote Operations Centre (BSROC), located in Brussels.

Telescience is the monitoring and control of onboard experiments from remote scientific centres and will take on great significance when the International Space Station becomes fully operational at the beginning of the 21st century.

In the Vertical Processing Facility on 21 September 1994, the CRISTA-SPAS payload is being moved into a test cell for Cargo Integration Test Equipment (CITE) testing.

NASA



Essentially, remote operations will give scientists and engineers the opportunity to participate actively and in real time in payload operations during the performance of experiments.

Such direct action means that commands can be issued from scientific centres all over Europe instead of solely from the Mission Control Centre in USA - and that science and house-keeping data can be received at the laboratory where the experiment was devised and designed, making their evaluation and interpretation much more rapid in cases where time is of the essence.

This also means a greater number of scientists can be involved in the space-based experimentation and that the science return may be greatly improved.

The ATLAS-3 mission was a further opportunity for ESA to develop its capability in telescience, building on the success in this area with the STS-65 IML-2 mission (*Spaceflight*, October 1994, p.338).

Most of the ATLAS instruments operate in an automatic mode, but crewmembers and ground-based investigators in Europe and the US can use keyboards to enter or alter observation parameters if necessary. This was the case with the European instruments

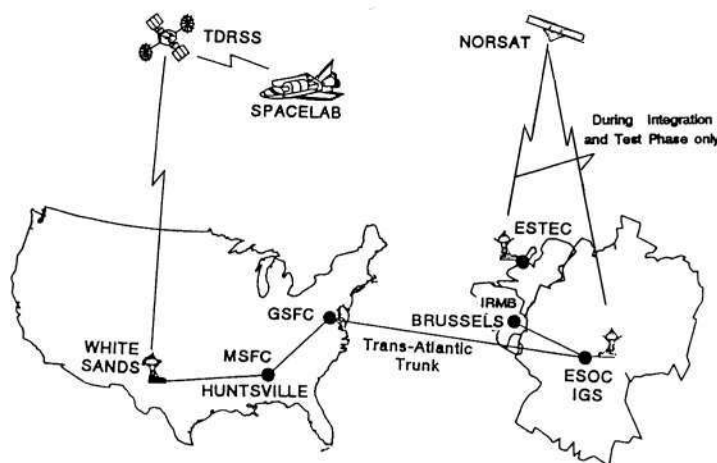
(SOLCON and SOLSPEC) whose operation was controlled from Brussels where co-investigations were located.

SOLCON instrumentation is supported by the Royal Meteorological Institute of Belgium in Brussels and is the responsibility of Dr Dominique Crommelynck. Its periodical use on the Shuttle is important to help detect drifts of measurements being made by satellite instruments, bringing them in line with the Space Absolute Radiometric Reference established for the first time during the ATLAS-2 mission.

SOLSPEC instrumentation is the responsibility of Dr Gerard Thuillier of the Aeronomy Service of the National



Jean-Francois Clervoy during training on the Shuttle simulator. ESA

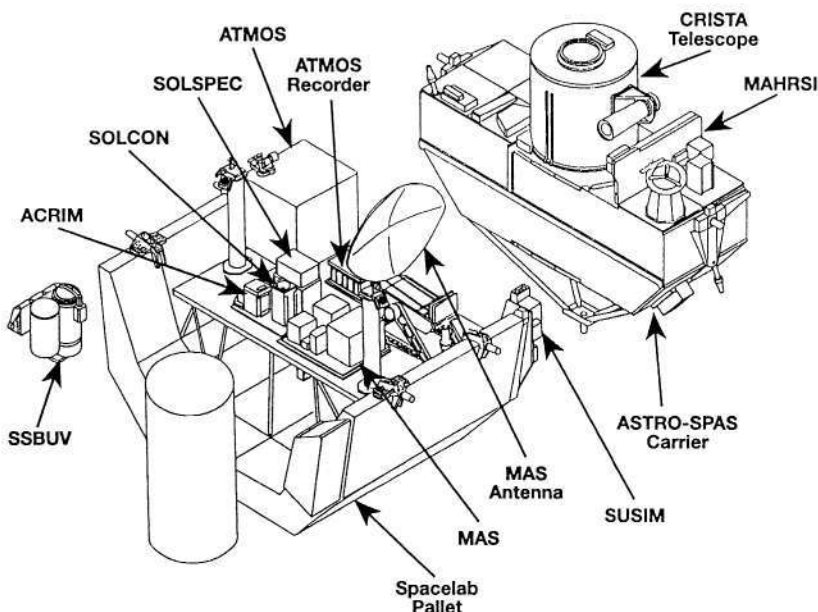


Communication links for the ATLAS-3 mission.

The CRISTA-SPAS payload carries two instruments for studying atmospheric physics, namely CRISTA (Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere) and MAHRSI (Middle Atmosphere High Resolution Spectrograph Investigation).

The ATLAS-3 payload has two instruments for atmospheric studies, namely ATMOS (Atmospheric Trace Molecule Spectroscopy) and MAS (Millimetre Wave Atmospheric Sounder); and four instruments for solar studies, namely ACRIM (Active Cavity Radiometer Irradiance Monitor), SOLCON (Solar Constant), SOLSPEC (Solar Spectrum) and SUSIM (Solar Ultraviolet Irradiance Monitor).

The SSBUV (Shuttle Solar Backscatter Ultraviolet) experiment makes spectral observations related to atmospheric gases and variations in the reflectivity of Earth surface features such as clouds, oceans and deserts. NASA



Centre for Scientific Research, France and was developed jointly by that institute and the Space Aeronomy Institute of Belgium. It operates at wavelengths from 180 to 3200 nanometres where solar radiation varies significantly during the 11-year solar cycle. Previous SOLSPEC flights were on the Spacelab 1 and the ATLAS 1 and 2 missions.

MAS and CRISTA are German experiments. MAS instrumentation is the responsibility of Dr Gerard Hartman of the Max-Planck Institute for Aeronomy, Katlenburg-Lindau, Germany. CRISTA is provided by the University of Wuppertal, Germany with funding from the Germany Space Agency (DARA) and has Dr Dick Offerman as Principal Investigator. ESA

ESA Astronaut Uses Newest Canadarm

Canadarm 202, the newest member of the Spar Aerospace fleet of robot manipulators, made its debut aboard STS-66. Canadarm 202 is the fifth arm Spar has built for NASA. Previous arms were delivered in April 1981, January 1983, December 1983 and March 1985.

During the eight days of the CRISTA-SPAS free flight, Canadarm was kept in an extended park position to keep it out of the field-of-view of an ATLAS 3 payload that was operating from the shuttle cargo bay.

At the end of its free flight, Jean-Francois Clervoy grappled the CRISTA-SPAS satellite with the Canadarm and berthed it in the cargo bay for its return to Earth.

Canadian robotics is set to play a significant role in space with development currently underway at Spar Aerospace on the Mobile Servicing System which will be used to assist in the assembly and maintenance of the International Space Station. ■

Spacehab 'Back To Business' for Busy Third Flight

Satellite Deployment, Mir Rendezvous and Spacewalk Planned

When the Space Shuttle Discovery reaches orbit in February 1995 to begin the eight-day STS-63 mission, her six-member crew - including the Russian cosmonaut Vladimir Titov - will be starting a series of up to ten joint flights between the two former superpowers, preceding the construction of the International Space Station. During the mission, the crew plans to manoeuvre the Shuttle to within 100 ft - and possibly as close as just 30 ft - of the Mir orbital complex, in readiness for an actual docking by Discovery's sister ship Atlantis in May 1995.

In addition to the rendezvous commitment, the crew will perform numerous scientific and technological experiments within the commercial Spacehab facility, deploy and later retrieve a free-flying satellite, and perform a spacewalk to prepare for Space Station assembly activities.

Spacehab Experiments

The third flight of Spacehab, which has been designated as STS-63's primary objective, was originally scheduled for a May 1994 launch but was postponed by several months owing to a shortage of payloads. Spacehab Inc., the private concern responsible for developing and marketing the system, had anticipated a large number of customers for microgravity research following the first mission in June 1993, but were largely disappointed.

For STS-63, 17 of the 20 experiments inside Spacehab have received either partial or total sponsorship from NASA centres, while the remaining three are provided by the US Department of Defense (DoD). The Canadian Space Agency (CSA) and the US National Institute of Health (NIH) have also participated in the development of two NASA experiments.

Mission Schedule

If all goes according to plan, Discovery will lift-off from the Kennedy Space Center (KSC) in Florida at 12:50 am EST on 2 February 1995, at the opening of a five-minute 'launch window' for

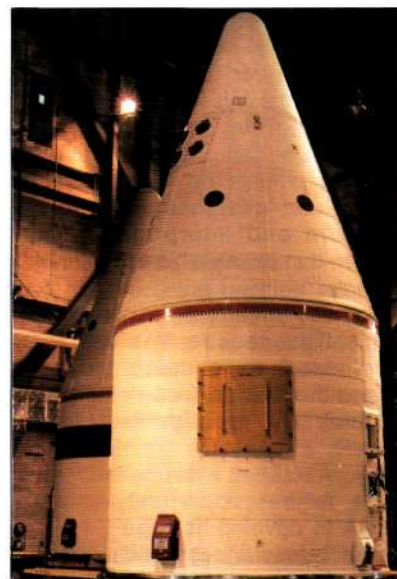
BY BEN EVANS

West Midlands, UK

that day. The spacecraft will follow a direct-ascent trajectory into its 170 nautical mile-high orbit, inclined at 51.6 degrees to the equator. Several additional thruster-firings will then be required for the planned rendezvous with Mir on Flight Day Seven.

Spacehab Operations

Almost immediately after orbital insertion, the crew will settle down to activating the large cargo complement housed in Discovery's 60-ft-long payload bay. The main payload element, the Spacehab-3 module, occupies the forward quarter of the bay and will act as a 'second middeck' for the storage and operation of commercial science experiments. Spacehab activities will commence approximately three hours after launch, and continue throughout the mission until the module is deactivated shortly before the scheduled landing. Mission Specialist Titov has been designated as the lead crew member for Spacehab experi-



STS-63 booster forward skirts with frustums in the VAB low bay on 9 October 1994.

PETER QUALTIERI/WEST KENTUCKY NEWS

ments, while Payload Commander Harris has responsibility for the systems aboard the module. In addition, Titov and Ford are trained as Spacehab In-Flight Maintenance crew members.

Astronomical Research

Also in the payload bay is the Shuttle-Pointed Autonomous Research Tool for Astronomy (SPARTAN)-204, a free-flying satellite which will be deployed by cosmonaut Titov during the second day of the STS-63 mission. SPARTAN is a small cube-shaped craft designed for up to two days of untended free-flight alongside

HOW BIG IS BIG? The size of the ET is best appreciated at close quarters. The photos below show the ET for STS-63 before it entered the VAB on 21 September 1994. The lightning rod and LOX vents are clearly visible on the nose cap in the left photo. Starting from there and running the entire length of the tank is the cabletray/range safety ordnance. The 17 in LOX feed comes out of the intertank and runs to the aft orbiter and umbilical points. The SRB fitting is located halfway down the side of the intertank and the transporter is also attached there. The lower two SRB attach points

are along the side of the bottom, silhouetted against the sky.

In the right photo, the 154 ft ET is dwarfed by the 525 ft VAB. If the tank were placed vertically over the US flag on the VAB starting from the lower left corner it would only cover 3½ stripes and extend from the bottom of the flag to the fourth row of stars. In fact it would nearly fit vertically through the three open sections of the high bay doors to the right where the height of the gap is 147 ft.

PETER QUALTIERI, WEST KENTUCKY NEWS



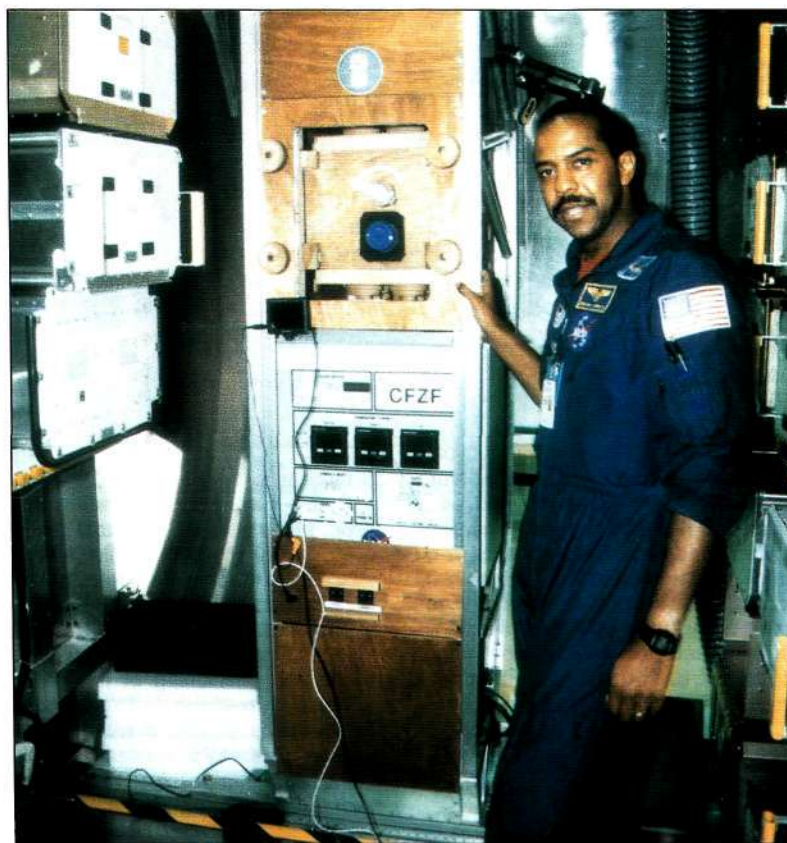
the orbiter. Unlike similar concepts such as SPAS and ASTRO-SPAS, the SPARTAN programme is completely dedicated to two closely-related scientific disciplines: astronomy and astrophysics, having been used on several occasions to transport ultraviolet and X-ray instruments into low-Earth orbit with a high degree of success.

According to Mission Specialist Ford, who will retrieve the satellite by means of Discovery's RMS arm on Flight Day Four, SPARTAN will be equipped with a Far Ultraviolet Imaging Spectrograph (FUIS), provided by the Naval Research Laboratory (NRL). The FUIS instrument will obtain data on man-made and naturally-occurring ultraviolet radiation in space, in addition to measuring the Sun's energy flux at extreme-ultraviolet wavelengths.

After the retrieval, however, SPARTAN's job will not yet be complete, since it will feature in a spacewalk by Payload Commander Harris (EV1) and Mission Specialist Foale (EV2) on Flight Day Five. The two astronauts will spend between four and six hours outside the orbiter, performing further tests and evaluations as part of NASA's ongoing preparation effort for Space Station construction and maintenance. Among their many tasks, Harris and Foale will attempt to manoeuvre the SPARTAN by hand to simulate moving large masses in the microgravity environment. Assisting them with the RMS will be astronauts Ford and Titov, while Pilot Collins will act as the 'intravehicular' crew member to monitor the proceedings.

Other Experiments

The third major payload aboard Discovery is a single Mission-Peculiar Equipment Support Structure (MPESS) carrier system, a bridge-like



Bernard A. Harris in the training module at "Spacehab" preparing for his flight aboard STS-63 in February 1995.
E. RUDOLF VAN BEEST

assembly sitting astride the payload bay. For STS-63, the MPESS will be fitted with three main experiments: namely the Consortium for Materials Development in Space-Complex Autonomous Payload (CONCAP)-II, the Orbital Debris Radar Calibration Spheres (ODERACS)-2 and the Cryo Systems Experiment GLO-II Payload (CGP).

CONCAP-II, which flew aboard the STS-46 mission in July 1992, is an experiment to investigate the reactions of numerous materials - including high-temperature supercon-

ducting films - with atomic oxygen in low-Earth orbit to assess their degradation through exposure for long periods. The ODERACS-2 payload will involve the release into space of six stainless-steel spheres, ranging in diameter from two to six inches, for purposes of calibrating ground-based radar systems. The Cryo Systems Experiment portion of CGP will demonstrate a cryogenic system for cooling focal-plane optics on future space-based scientific instruments, while the GLO-II element will make observations of the Earth's thermosphere, ionosphere and mesosphere, together with the mysterious Shuttle 'surface glow' phenomenon.

Two further experiments will also be carried out by the crew. The Air Force Maui Optical Site (AMOS)-20 investigation, which is a relatively simple payload, will use the orbiter as a moving target to help calibrate US Air Force ground-based electro-optical sensors on the Hawaiian island of Maui and also study on-orbit plume phenomenology. The Solid Surface Combustion Experiment (SSCE)-6, located in a middeck locker, will demonstrate flame propagation across solid-fuel surfaces under microgravity conditions.

Assuming an on-time launch, Discovery will touchdown on 10 February at either the KSC Shuttle Landing Facility (SLF) runway or Edwards Air Force Base in California, after a mission duration of some eight days and five hours.

About the Crew

Discovery's crew is led by US Navy Commander **James D. Wetherbee**, 42, who has been an astronaut since May 1984 and will be undertaking his third space flight having previously served as Pilot of STS-32 in January 1990 and Commander of the STS-52 mission in October 1992.

Sitting alongside Wetherbee on Discovery's flight deck will be 38-year-old **Eileen M. Collins**, the first female Shuttle Pilot and the only member of the STS-63 crew not to have flown before, having been an astronaut since January 1990.

Mission Specialist-One (MS1) will be **Dr Bernard A. Harris**, 38, who is also designated 'Payload Commander' and in this capacity will exercise overall crew responsibility for payload science activities. He is a veteran of the STS-55 mission in April 1993 and an astronaut since January 1990.

Mission Specialist-Two (MS2) is British-born **Dr C. Michael Foale**, 38, who will occupy the centre seat behind the Commander and Pilot as 'flight engineer' during the ascent and entry phases of STS-63. He previously took part in the STS-45 and STS-56 missions in March 1992 and April 1993 respectively and was selected as a NASA astronaut in June 1987.

Mission Specialist-Three (MS3) is **Dr Janice E. Ford** (nee Voss), 38, a veteran of the first Spacehab flight STS-57 in June 1993 who joined the NASA astronaut corps in January 1990.

Mission Specialist-Four (MS4) is Russian Air Force Colonel **Vladimir G. Titov**, 48, who already has two flights under his belt, including the record-breaking 366-day Soyuz TM-4 mission of 1987-88. Prior to this, he commanded the unsuccessful Soyuz T-8 flight to Salyut-7 in April 1983 and has been a cosmonaut since February 1976.

Earth Observation Technology

Monitoring Projects Get International Priority

The 45th IAF Congress, Jerusalem focused mainly on the technology for Earth Observations although other activities such as space transportation (*Spaceflight*, December 1994, p.398) maintained great interest. Remote sensing concerned the development of new instruments for atmospheric, meteorological and oceanic studies and related satellite launches. The use of high-resolution pictures, through commercial ventures, did not, however, come over as a priority subject.

The Future of the SPOT System

SPOT-4 with enhanced sensors will be launched by the end of 1997. The SPOT 4 satellite, which is in course of production, uses a new MkII version of the platform, strengthened and more powerful and with an increased lifetime of 5 years. The two HRVIR instruments, derived from the current HRV instruments, contain a new channel in the medium-infrared range and thus satisfy the need for applications linked to the analysis of vegetation and harvest forecast. The payload has two new passengers:

- An instrument (Vegetation Monitoring Instrument) which also enables improved monitoring of vegetation by daily coverage of the globe with a resolution of 1 km, working in the same bands as the HVRIR instruments, but with a much larger view which makes it complementary to high-resolution instruments.
- The PASTEL optical link terminal developed by Matra Marconi Space, which will enable experiments to be carried out on high-speed inter-orbital laser communications as part of the European Space Agency's SILEX programme.

SPOT-5A and 5B, recently approved by the French government, will use a new and largely improved instrument, called the High Resolution Geometry (HRG). It will transmit data at the rate of 150 Mb/s. Three HRGs, each able to achieve 5-m resolution images, will form the payload: one looking forward, one looking down and the third aft. They will work in three modes:

- The high-resolution mode will go from 10 m to 5 m resolution and from one spectral band to four (panchromatic at 5 m, the three bands at 10 m).
- The multispectral mode will go from 20-m to 10 m resolution with the same spectral bands.
- The stereo mode (with stereopairs acquired within seconds of each other) will go from 10 m to 5 m resolution and from one spectral band to two.

SPOT-5A will be ready for launch in late 1999 with a nominal launch date some time in 2002. SPOT-5B has to be ready for early 2003 with a nominal launch date in 2007.

China's Meteorological Satellites

The Shanghai Institute of Satellite Engineering (SISE) of the Chinese Aerospace Corporation (CASC) announced:

- The launch in the late 1990s of the

BY THEO PIRARD, FBIS
Belgium

three-axis stabilised FY-1C and FY-1D (Feng-Yun, first generation of polar-orbit meteorological satellites), carrying a 10-channel visible and infrared scanning radiometer with a resolution of 1.1 km.

- The launch of the geosynchronous FY-2 satellite during the following months and the positioning of it at 105° East. This spin-stabilised meteorological satellite is equipped with a multi-channel visible (1.25 km resolution) and infrared (5 km resolution) scanning radiometer covering China, Oceania and the Indian Ocean.
- The development of second generation polar satellites FY-3, using advanced multispectral optical sensors (for three-dimensional atmospheric observations) and multichannel passive sensors (for quasi-all weather observations).
- The development of a satellite with Synthetic Aperture Radar or SARsat to monitor the Earth in an all-weather mode.

International Coordination

A joint presentation by NOAA and Eumetsat emphasised the need for international cooperation in the development and use of meteorological satellites giving a worldwide listing of geostationary and polar meteorological satellite to be launched during the next 10 years. (See Tables 1 and 2).

Europe's Polar Spacecraft

Envisat-1, developed by ESA, will be the most complex and heaviest spacecraft to be prepared for remote sensing operations. This six-ton satellite, using an advanced SPOT MkII service module will carry a payload of two tons combining optical and microwave sensors.

It will consist of an advanced Synthetic Aperture Radar (ASAR), a Medium-Resolution Imaging Spectrometer (MERIS), a Radar Altimeter (RA-2), a Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) and an instrument for a Global Ozone Monitoring by Occultation of Stars (GOMOS).

Four of Envisat-1's instruments are still in the phase of Announcement of Opportunity: Advanced Along Track Scanning Radiometer (AATSR), DORIS (Doppler Orbitography and Radiometer Integrated by Satellite) proposed by France, SCIAMACHY (Scanning Imaging

Absorption Spectrometer for Atmospheric Cartography) proposed by Germany, and SCARAB (Scanner for Radiation Budget). It will be launched in December 1998 by Ariane 5 into a near-circular orbit between 780 km and 820 km.

METOP, developed by ESA for Eumetsat, will be the first in a series of European polar spacecraft for meteorological observations. The launch, with an Ariane vehicle, of this 2.5-ton spacecraft is planned by the end of the year 2000.

The international payload of 960 kg will consist of an Advanced Very High Resolution Radiometer (AVHRR/3), a High Resolution Infra-Red Sounder (HIRS/3), an Advanced Microwave Sounding Unit (AMSU), a Microwave Humidity Sounder (MHS), a Data Collection System (DCS/2), an Infra-Red Atmospheric Sounder Interferometer (IASI), plus an Advanced Wind Scatterometer (ASCAT), a Multi-Frequency Imaging Microwave Radiometer (MIMR), a Scanner for Radiation Budget (SCARAB) and a Global Ozone Monitoring Experiment (GOME).

Brazil in Space

Brazil is using Landsat and SPOT images to map the Amazonian region and to follow the rate of deforestation. It is preparing its own systems for the 1990s with indigenous minisatellites and Chinese platforms:

- SSR is a 170-kg, three-axis stabilised spacecraft with a solid-state push-broom camera to take pictures of 210 m resolution in the visible and near infra-red spectral bands. It will be placed in a Sun-synchronous orbit at 640 km by the Brazilian VLS, first launch of which is expected to take place during 1995.
- CBERS is a joint venture between China and Brazil: it concerns a 1.4 t spacecraft with a Wide-Field Imager (WFI), a High-Resolution CCD Camera (HRC) and an Infrared Multispectral Scanner (MSS). The HRC and the MSS will be able to provide detailed information over a nearly 120 km swath width with, respectively, 20 and 80 m resolutions. It will be placed in Sun-synchronous orbit at 778 km by a Chinese Long March 2D vehicle.

Ukraine's Microwave Expertise

The Ukraine is active in the field of microwave remote sensing operations with side-looking radars and synthetic aperture radars. These microwave sensors are used aboard the Okean-type spacecraft. It will launch its first remote sensing satellite named Citch-1 in 1995.

Start of the Earth Observing System (EOS) Series

NASA is preparing for an Atlas 2AS launch from Vandenberg AFB in June 1998 of the EOS-AM1 spacecraft.

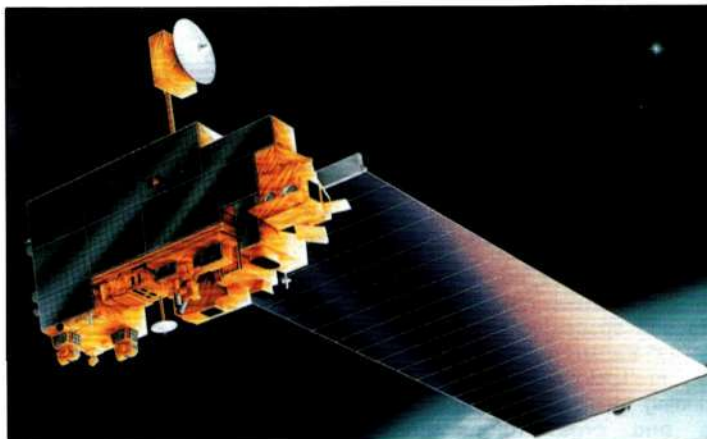
This 5,186 kg remote sensing satellite, developed by Martin Marietta Astro Space, will carry a 1,155 kg payload consisting of the Moderate Resolution Imaging Spectroradiometer (MODIS), the Clouds and Earth's Radiant Energy System (CERES), the Multi-angle Imaging Spectro-Radiometer (MISR), the Advanced Space Thermal Emission and

Reflection Radiometer (ASTER of Japan), which includes a VNIR (Visible and Near-Infrared Radiometer) having 15 m spatial resolution, and the Measurement Of Pollution In The Troposphere (MOPITT of Canada). It will be placed in Sun-synchronous orbit at 705 km.

Japan's Extended Programme

Japan is developing satellite payloads for the ADEOS (Advanced Earth Observing Satellite) and ALOS (Advanced Land Observing Satellite) programmes:

- ADEOS-1, which is being prepared for launch by H-II in early 1996, is designed to monitor global environmental changes. The 3.5 ton spacecraft will carry a NASA Scatterometer (NSCAT), the Total Ozone Mapping Spectrometer (TOMS) of NASA, the Polarization and Directionality of the Earth's Reflectance (POLDER) of France, Interferometric Monitor for Greenhouse Gases (IMG) and the Improved Limb Atmospheric Spectrometer-II (ILAS).
- ADEOS-II is planned for launch in 1999 and will also be developed with international cooperation. The 3.5 ton class satellite will be placed by H-II in Sun-synchronous orbit at 803 km. Its payload will consist of an Advanced Microwave Scanning Radiometer (AMSR), of a Global Imager (GLI), an Improved Limb Atmospheric Spectrometer-II (ILAS-II), the SeaWinds Scatterometer of NASA/JPL and the Polarization and Directionality of the Earth's Reflectance (POLDER) of France.
- ALOS is under consideration for a



An illustration of the first payload (EOS-AM1) of NASA's Earth Observing System scheduled for launch in June 1998.

launch in 2000-2001 with an H-II vehicle. It will observe the change of land use and the progress of natural disasters with the use of high-resolution visible and infrared radiometer and of a synthetic aperture radar.

India's Improved Satellites

India is preparing remote sensing satellites with new and upgraded capabilities.

- The IRS-1C and IRS-1D, planned for launch during 1995-97 timeframe, form the second generation of Indian remote sensing satellites. They will carry optical sensors with enhanced capabilities (better than 6 m in the panchromatic band) and with wide-field and stereosensing possibilities (of better repeti-

ty). Their payloads will consist of a multispectral Linear Imaging Self Scanner (LISS/3), a Short Wave Infrared camera (SWIR), a Panchromatic Camera (PAN) for high-resolution pictures and a Wide Field Sensor (WIFS).

- The IRS-P3, which is being prepared for launch with the third Indian PSLV rocket, will be an IRS-1A type satellite carrying the Modular Opto-Electronic Scanner (MOS). This sensor developed by DLR in Germany will help the study of ocean productivity.
- The Oceansat spacecraft, currently being studied by ISRO, is a dedicated satellite for mapping and monitoring ocean resources. It will carry an ocean colour monitor, a scatterometer, an altimeter, a thermal infrared sensor and a passive microwave radiometer. ■

Meteorological Satellites Scheduled for Launch During the Next 10 Years

Table 1: Polar-Orbiting Meteorological Satellites.

Operator/ Satellite	Launched	Orbit	km	Status/ Launch Date
EUMETSAT				
Metop-1	-	am	827	2000
Metop-2	-	am	827	2005
Metop-3	-	am	827	TBD
NOAA				
NOAA-11	09/1988	pm	850	Operational
NOAA-12	05/1991	pm	850	Operational
NOAA-J	-	pm	850	12/1994
NOAA-K	-	am	850	04/1996
NOAA-L	-	pm	850	1997
NOAA-M	-	am	850	1998
NOAA-N	-	pm	850	2000
NOAA-N'	-	pm	850	2003
NPOESS-1	-	-	824	2006
NPOESS-2	-	-	824	TBD
NPOESS-3	-	-	824	TBD
PRC				
FY-1 C	-	-	870	Late 1990s
FY-1 D	-	-	870	Late 1990s
Russia				
Meteor 2-21	08/1993	-	1200	Operational
Meteor 3-5	08/1991	-	1200	Operational
Meteor 3-7	01/1994	-	1200	Operational
Meteor 3-8	-	-	1200	1996
Meteor 3M-1	-	-	925	1998
Meteor 3M-2	-	-	925	2000

Table 2: Geostationary Meteorological Satellites.

Operator/ Satellite	Launched	Location	Status/ Launch Date
EUMETSAT			
Meteosat 3	06/1988	75°W	GOES Replacement
Meteosat 4	03/1989	0°	Backup to Meteosat 5
Meteosat 5	03/1991	0°	Operational
Meteosat 6	11/1993	0°	In Commissioning
Meteosat 7	-	0°	Mid-1997 for MTP
MSG 1	-	0°	2000
MSG 2	-	0°	2002
MSG 3	-	0°	2006
India			
INSAT I-d	06/1990	83°E	Domestic Operational Use
INSAT II-a	07/1992	74°E	Partial Operational Use
INSAT II-b	07/1993	93.5°	Domestic Operational Use
INSAT II-e	-	TBD	1997/98
Japan			
GMS-3	08/1984	120°E	Back-up of GMS-4
GMS-4	09/1989	140°E	Operational
GMS-5	-	140°E	Early 1995
MTSAT-1	-	140°E	1999
USA			
GOES-7	02/1987	112°W	Operational
GOES-8	04/1994	98°W	In Commissioning
GOES-J	-	TBD	06/1995
GOES-K	-	TBD	1999
GOES-L	-	TBD	2000
GOES-M	-	TBD	2004
Russia			
Elektro-1	-	76°E	Launched 31/10/94
Elektro-2	-	76°E	1997
PRC			
FY-2	-	105°E	TBD

SPOT 3 Launch was an Unforgettable Event

Launch Success Came in the Last Minute

Spot 3, designed and developed by the French Space Agency CNES, was launched at 01:45 UTC on 26 September 1993 from the Guiana Space Centre at Kourou, French Guiana. The satellite went into orbit atop an Ariane-40 launch vehicle (flight V59).

CNES, Spot Image and industrial firms participating in the Spot programme invited guests and space industry personalities to a "live" transmission, via a direct satellite link, in Toulouse. Almost 2000 guests, including members of staff of the companies and organizations concerned, gathered for an exciting evening punctuated by reports from the Jupiter control room at Kourou and the main control room at the Toulouse space centre.

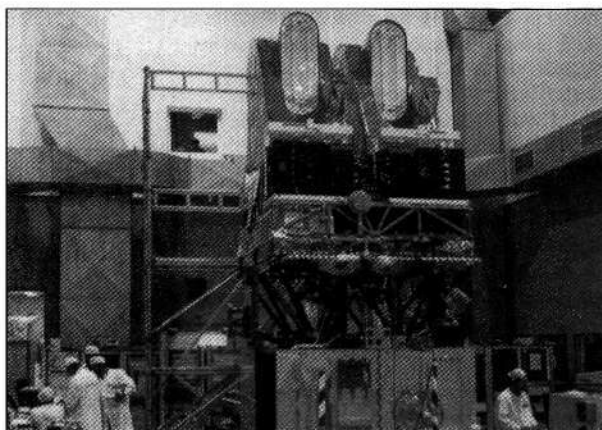
The launch, initially scheduled for 25 September 1993, had to be postponed for 24 hours due to poor weather conditions. The announcement brought smiles and a touch of disappointment, though every-

one acknowledged the importance of optimal safety for a successful launch.

The second night produced more suspense. The countdown was interrupted no less than three times, with launch finally taking place during the very last minute of the 18-minute launch window. Suspense and intense excitement gave way to relief accompanied by enthusiastic applause. Spot 3 was on its way and, in the time-honoured tradition, champagne glasses were raised and the event celebrated until

Some particularly attentive guests during the final minutes of the countdown. Front row, from left to right: J.C. Husson (Alcatel Espace), G. Brachet (Spot Image), M. Courtols (CNES, French Space Agency), C. Goumy (Matra Marconi Space), J.D. Levi (CNES), F. Fillon (French Minister of Higher Education and Research), D. Maugars (Deputy Directeur du Cabinet, Ministry of Higher Education and Research) and General Vougy (special adviser to the President of the French Republic for Defence and Weapons).

SPOT IMAGE



Spot 3 at the Matra Marconi Space plant, Toulouse. MMS

late into the night.

The Spot 3 programme received French government approval in 1987. Following on from Spot 1 (launched in 1986) and Spot 2 (launched in 1990), Spot 3 will ensure continuing image acquisition and production capabilities. In their first seven years of uninterrupted service, Spot 1 and 2 have recorded almost three million images.

Aside from some important improvements, Spot 3 is identical to its predecessors. The new on-board recorders should ensure a longer operational lifetime. These feature harder, low-wear heads, a new type of magnetic tape, and active tape guides to prevent the tape edges rubbing against mechanical components. Overall, the recorders will be less prone to wear and produce less tape debris.

Spot 4, the successor to Spot 3 is already planned to be launched in 1997.

The Spot programme is developed by France in cooperation with Belgium and Sweden, and with the participation of the IGN (Institut Géographique National).

An edited version of a report in Spot Flash, No. 12, October 1993, published by Spot Image.



Satellite Data for the Environment

Developing Dialogue between Satellite Operators and Potential Users

CEOS (Committee on Earth Observation Satellites) was founded as a G-7 initiative 10 years ago to optimise the benefits of Earth Observation by serving as a platform for coordination between both space agencies and international user communities.

In 1994 CEOS consisted of 19 member agencies, 6 observers, including the European Union, and 9 international affiliate organisations (e.g. WCRP, WMO, UNEP).

CEOS celebrated its 10th anniversary in Berlin on 28 September 1994.

The past two years have seen a lot of activity intended to focus attention on the use of satellite data for environmental purposes. In Europe the CEOS initiative was started by the CEOS meeting in

London in April 1992 which was in the context of UNCED in Rio de Janeiro later that same year.

In November 1992 the German authorities sponsored an important conference in Bonn which confirmed the need for systematising environmental data needs.

The European Commission then took over the relay and, after consultation with Member States, Directorate General XII awarded a contract to Scot Conseil and Smith System Engineering Limited for a study on the existing and potential use of satellite data for environmental purposes in the European region. This study was presented and discussed at a workshop held in Brussels on 8-9 March 1994 attended by around one hundred representatives from environmental agencies and ministries, as well as space agencies.

The study prepared for the European Commission provides a checklist for

environmentalists, indicating which satellite instruments and missions are of potential interest over the next 15 years and presents space agencies with user-specified environmental monitoring requirements. The study was initiated to improve the dialogue between space agencies and environmental users of satellite data. The work of both are evolving fields with changing priorities and therefore the study, which provides a 1993-94 user-driven view, will need to be updated regularly. Smith System Engineering are located at Surrey Research Park, Guildford.

EURISY is currently (December 1994) holding a colloquium in Vienna on "Earth Observation by Satellite: An Opportunity for Mankind in the 21st Century". The contribution made by Earth observation satellites to many areas of European policy is still insufficiently acknowledged. The dialogue between satellite operators and potential users needs to be developed. Such is the objective of the Vienna colloquium to be attended by politicians, decision-makers, scientists, users and industrialists.

An edited version of reports in the EURISY Newsletter No. 16, April 1994, published by EURISY, Paris, France.

Finding Out About...



Environmental Monitoring from Space

Part I - Basic Technology

Suppose that, as part of your job, you had to survey the extent of destruction of the Amazonian rain forest by fire. On the ground the problem, with an area so vast, really would be one of "not being able to see the wood for the trees". Aerial surveys offer a limited solution, but only a relatively small area can be covered at a time and aeroplanes do have to keep returning to base. It is rather like jumping up and down to see what is beyond a high wall. Regular monitoring in detail of all parts of a large area over periods of weeks, months or years is impracticable.

Earth-orbiting satellites, which carry instruments to observe the Earth's land, sea and atmosphere, make this continuous monitoring possible, but in order to stay in orbit for a usefully long period, they have to be boosted to a height of at least several hundred km. At such heights their sophisticated optical systems produce images which may cover many hundreds of square km of the Earth's surface and yet objects as small as 10 m in size may be picked out.

As well as surveying damage to forests, due to natural causes as well as human, Remote Sensing (RS) satellites, as they are often called, are currently being used by geographers, oceanographers, geologists, agriculturalists, ecologists, town (and country) planners, atmospheric scientists and many others to study such diverse subjects as crop yields, the spread of deserts, environmental impact of industrial developments, pollution of all types, polar ozone "holes" and so on. The purpose of this article is to describe something of the capabilities of the satellite systems available, how they work and some of their applications.

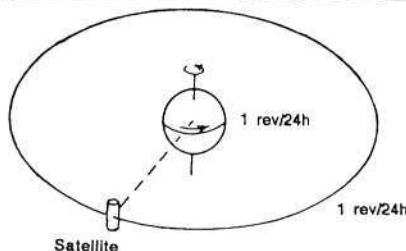
Earth Remote Sensing Satellites

Three types of spacecraft are in operational use:

Meteorological Satellites

Today, most of these orbit at a height of about 36,000 km above the equator. At this height, the time taken to complete one orbit is 24 hours, exactly the time taken for the Earth to complete one rotation about its axis. This type of orbit is called a geostationary or Clarke orbit (after the science fiction author Arthur C. Clarke, who first described its use) and from it the satellite always looks down upon the

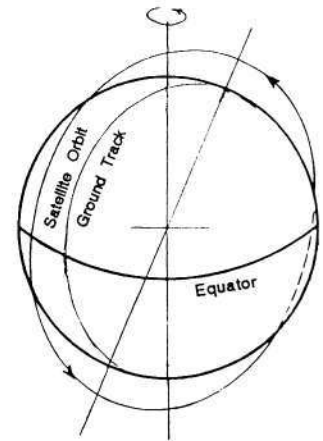
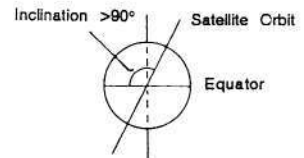
BY DR D.J. BELSON
Senior Lecturer
Faculty of Science,
The Nottingham Trent University



Satellite in geostationary orbit.

same part of the Earth's surface.

Meteorological satellites, such as Meteosat, Geostationary Operational Environmental Satellites and Geostationary Meteorological Satellites, are primarily designed to produce the images of cloud cover over large parts of the globe which are familiar from television weather forecasts. When there are no clouds, pictures of large



The Sun-synchronous near-polar orbit.

areas of the Earth's surface are obtained, but these lack the fine detail of images produced by spacecraft in lower orbits. However it is possible to receive these images directly, particularly from the European Space Agency's "Meteosats", with equipment available in many schools.

Manned Spacecraft

Astronauts and cosmonauts have taken many photographs of the Earth's surface, generally using hand-held cameras. Taken from orbital heights of 200-300 km, quite small objects can be made out on them, for instance individual tankers at sea bilging their tanks can be tracked. When taken at an oblique angle in low sunlight, greater relief is obtained and, with the natural colour, these views are easier to understand and interpret than overhead views. However, monitoring from current manned spacecraft has the same drawbacks as using aerial surveys. Photographs can

Table 1: Operational Earth Remote Sensing Satellite Systems.

Satellite	Operational Dates	Orbital Data
Landsat		Altitude: 919 km
1	1972-78	Inclination: 99.1°
2	1975-82	Period: 103 min
3	1978-83	Equator crossing time: 9.30 am (local time)
Landsat		Altitude: 705 km
4	1982-date	Inclination: 98.2°
5	1984-date	Period: 99 min
		Equator crossing time: 9.45 am (local time)
SPOT		Altitude: 830 km
1	1986-date	Inclination: 98.7°
2	1990-date	Period: 101 min
3	1993-date	Equator crossing time: 10.30 am (local time)
ERS		Altitude: 785 km
1	1991-date	Inclination: 98.5°
		Period: 100 min
		Equator crossing time: 10.30 am (local time)

SPACE EDUCATION

only be taken while the astronauts are up there and free of other commitments.

Purpose-Built RS Satellites

Since 1972, several spacecraft have been launched to provide continuous monitoring of the Earth's surface. They occupy near-polar orbits at heights between 700 and 1000 km. That means they pass very close to both north and south poles on each orbit. The advantages of this type of orbit are that:

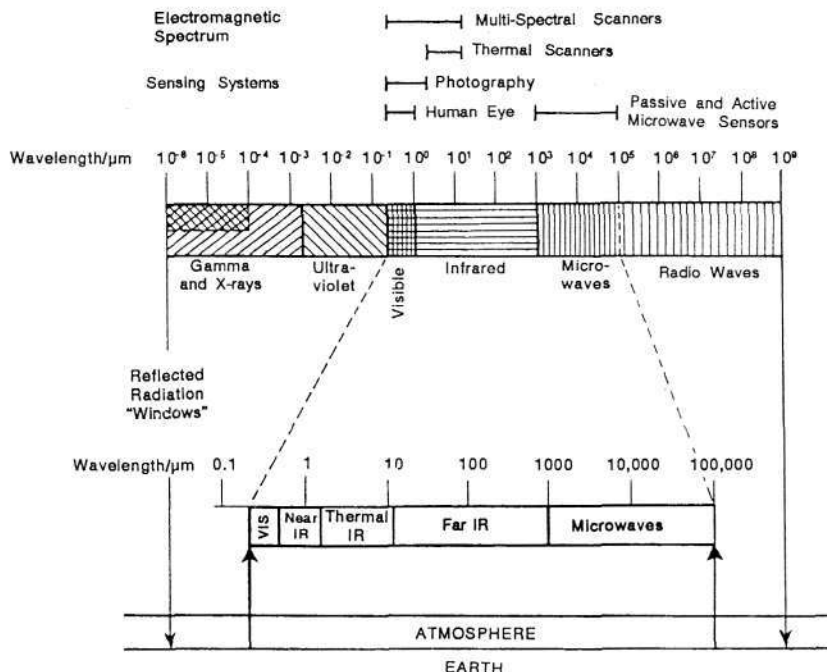
- quite a small area of the Earth's surface is covered by each image at remarkably high resolution;
- the swathe of surface viewed on a particular orbit (the satellite's "ground track") is repeated every two to four weeks. This means that a particular small area is imaged repeatedly with that frequency;
- each image of a given small area is obtained under the same sunlight conditions (the orbit is "sun-synchronous").

Remote Sensing Satellites in Polar Orbits

There are currently three operational systems in polar orbit for which Orbital details are given in Table 1:

1. Landsat (USA): The first RS Earth satellite was Landsat 1 in 1972. There have been five more spacecraft in the series but Landsat 6 was lost after launch in October 1993.
2. Satellites Pour l'Observation de la Terre (France): SPOT 1, SPOT 2 and SPOT 3 are currently operational and SPOT 4 is scheduled for 1996.
3. European Remote Sensing system (European Space Agency): ERS 1 was launched in May 1992 and ERS 2 is scheduled for 1995.

All three systems are operated by commercial organisations who also



market, in this country, "off-the-peg" images from their archives and "made-to-measure" images to suit customers' requirements.

Other countries have, or are developing, RS spacecraft, namely India (IRS), Japan (MOS, JERS), Canada (Radarsat), Brazil and the USSR and its successors (Resurs). In brackets are shown the names or acronyms of the particular satellites.

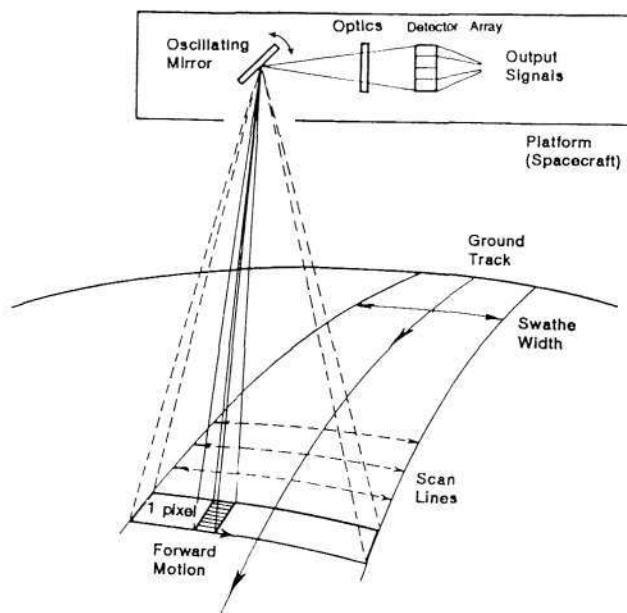
Function and Design of Sensors

RS satellites carry sensors which detect and record electromagnetic radiation reflected or emitted from the Earth's surface. This radiation is mainly reflected sunlight, most of which is absorbed by the Earth's atmosphere before reaching the spacecraft. The only solar radiation that passes through the atmosphere unaf-

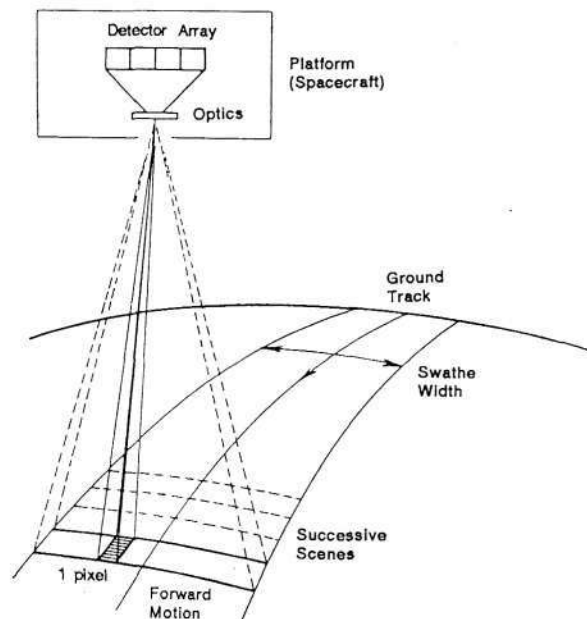
ected by absorption lies in the visible and infrared regions and also at the very short wavelength end of the radio region, the microwave region. It is through these "windows" that RS sensors detect emissions from the Earth's surface.

The information available from a photograph (an image produced on film sensitive to only the visible and near infrared) is limited. Landsats 1, 2 and 3 used Return Beam Vidicon (RBV) cameras, rather like TV cameras, to produce images in a similar way. These proved to have low sensitivity and a poor spectral range compared to instruments with sensors in which radiant energy received was converted directly into electronic signals which can be transmitted to Earth. The latter type have been the detectors of choice on all subsequent RS

"Whisk-Broom" Scanner.



"Push-Broom" Scanner.



spacecraft, apart from some short-lifetime Russian satellites.

Sensors which simply record electromagnetic radiation coming from the Earth's surface naturally (reflected or emitted) are called passive sensors. Active sensors emit electromagnetic radiation themselves and record that small part of it which is reflected back. (In the radio-region, this is a form of radar).

The detectors they use are tiny transducers, which convert electromagnetic radiation energy into electron currents, akin to "photocells". Charge-Coupled Devices (CCD's), which have also replaced photographic plates on most modern astronomical telescopes, are a particularly important type. An array of many of these detectors needs to be exposed to produce an image of each viewed area of the Earth's surface.

There are two types of visible/infrared detectors, differing in the ways in which they scan a scene to expose the sensors:

Optical Mechanical Scanners are otherwise known as "Whisk Broom" scanners because they use a rotating or oscillating mirror to sweep across a scene from side to side at right angles



This is a radar image taken on April 14, 1994 by SIR-C/X-SAR. It shows a dormant volcano in Colombia, the northern-most known in South America. The volcano is at 5.6 degrees north latitude and 75.0 degrees west longitude. The conspicuous dark region is a lake at the bottom of a 3 km caldera.

NASA/JPL

Table 2: Sensor Characteristics of Operational Earth RS Satellites.

Satellite	Instr.	Band	Wavelengths μm	Resolution m	Main Application Field
Landsat	MSS	4	0.50-0.60 (green)	80	Mapping of sediments, reefs etc. in shallow water.
		5	0.60-0.70 (red)	80	Man-made features - towns, roads etc.
		6	0.70-0.80 (red/near IR)	80	Vegetation studies, boundaries between landforms, land and water.
		7	0.80-1.10 (near IR)	80	As band 7; best penetration of atmospheric haze.
		8	10.40-12.50 (thermal IR)	120	Thermal imaging and mapping.
Landsat	MSS	1	Same as bands 4,5,6 and 7 respectively on Landsats 1,2 and 3.		
		2			
		3			
		4			
	TM	1	0.45-0.52	30	Coastal waters; differentiation of soil/vegetation, tree types.
		2	0.52-0.60	30	Vegetation mapping.
		3	0.63-0.69	30	Differentiation of plant species.
5	TM	4	0.76-0.90	30	Biomass surveys.
		5	1.55-1.75	30	Snow/cloud differentiation.
		6	10.40-12.55	120	Thermal mapping.
		7	2.08-2.35	30	Vegetation moisture, hydrated minerals.
SPOT	XS	1	0.50-0.59	20	Vegetation studies - these three bands give improved spectral response to three important absorption bands of chlorophyll.
		2	0.61-0.68	20	
		3	0.79-0.89	20	
2	HRV	PAN	0.51-0.73	10	Applications requiring fine geometric detail, e.g. cartography.

MSS - Multispectral Scanner.

HRV - High Resolution Visible imaging system.

PAN - Panchromatic (visible) mode.

TM - Thematic Mapper

XS - Multispectral mode.

to the direction of flight. (Compare the way a besom, or "witch's broom" is used). The mirror sweeps reflected light on to the detector array.

Linear Array Scanners are called "Push Broom" scanners. They use the forward motion of the satellite to sweep the linear array of detectors over the scene being imaged (in a similar fashion to the use of the more modern type of broom made of bristles).

Both the Multispectral Scanning System (MSS) and the Thematic Mapper (TM) used on successive Landsats are of the Whisk Broom type, while SPOT spacecraft carry High Resolution Visible imaging systems (HRV's), which are of the Push Broom type.

Detectors operating in the microwave region use antennae to receive electromagnetic radiation. Though these may not be circular dishes of the type used to receive satellite television broadcast signals, they work in the same way; for instance, the antenna of the Active Microwave Instrument on ERS-1 is rectangular. Modern sensors have several separate arrays of detectors, each responding to a different waveband, or narrow region of the electromagnetic spectrum. Images may either be produced separately from each waveband (multispectral) or by combining the whole lot (panchromatic - "over all colours").

The wavebands applicable to some current operational RS systems are given in Table 2. All the sensors listed are passive sensors operating in the visible and infrared regions. The ERS-1 satellite (Table 1) carries the Active Microwave Instrument (AMI) which, as its name implies, is an active sensor, employing radiation of 5.3 GHz frequency (this corresponds to a wavelength of 56600 μm). It gives a ground resolution of 30 m. ERS-1 also has on board, among other instruments, the Along Track Scanning Radiometer and Microwave Sounder (ATSR/M). This is a passive instrument scanning four wavebands in the infrared (1.6, 3.7, 10.8 and 12.0 μm) and two in the microwave region (36.5 GHz/8200 μm and 23.8 GHz/12600 μm), with a resolution of 1000 m. ERS-1 is intended for surveillance of the oceans and sea ice. The Japanese Environmental Remote Sensing Satellite, JERS-1, intended for terrestrial as well as oceanographic studies, has a similar complement of active microwave and passive visible, infrared sensors. JERS-1 was launched in February 1992. ■

Acknowledgement

The contribution of Max Wholey in the preparation of the diagrams is gratefully acknowledged.

Environmental Monitoring from Space, Part 2 on 'Data and Applications' will appear in a forthcoming issue.

Hot Stars in the Galactic Halo

S.J. Adelman, A.R. Uggren and C.J. Adelman, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 386pp, £40, ISBN 0-521-46087-5.

Our understanding of the "hot" stars that form a halo around our galaxy is undergoing a Renaissance as recent increases in the power of computers now allow a far more detailed and complete modelling of stellar evolution. The articles contained in this volume, drawn from a Conference to reexamine the subject, shows how advances in computer power have, in particular, allowed complex modelling to be made of the core helium-burning and ultraviolet-bright stages. The book goes on to demonstrate how this modelling is leading to a better understanding of new observations of Horizontal-Branch (HB) stars both in the field and in globular clusters, as well as stars in later stages of stellar evolution.

Together, these articles provide an up-to-date and comprehensive review of hot stars in the galactic halo, of the history of the halo itself and of the evolution of its old stellar populations of different metallicities.

Almanac of Soviet Manned Space Flight

Dennis Newkirk, Gulf Publishing Company, PO Box 2608, Houston, Texas 77252-2608, 391pp, 1990, £24.99 Hardback, ISBN 0-87201-848-2.

This is a well prepared book containing a wide range of useful information and a very useful reference source for readers seeking more than a general overview of the Soviet programme.

It has an innovative format which enables the reader to follow the launchings of the Soviet Space programme very easily and this is particularly useful e.g. with the multiple launches to the Salyut 6/7 and Mir Space Stations.

Another useful feature is the inclusion of precursor missions as well as unknown manned-related launches in the order of launch. Each mission has its own section containing details as known in 1990.

The use of line diagrams relating to hardware is very helpful in describing the lunar project, as are the black and white photographs in providing a key to the development of the former Soviet Union as a world leader until

Apollo 11. The book is well referenced and includes some useful chapters on such related hardware as boosters.

The 20-cm Schmidt-Cassegrain Telescope

P.L. Manly, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 265pp, £16.95, ISBN 0-521-43360-6.

This is a guide to the use of the world's most popular type of telescope, the 20-cm (8-inch) Schmidt-Cassegrain Telescope, a compact instrument which has so revolutionised amateur astronomy and astrophotography that more than 10,000 are now purchased each year.

The author, a keen user of the telescope, takes the new owner through all the aspects of using it in easy stages. He starts with techniques for viewing the Moon and then proceeds through the solar system and on to the deep sky, with nebulae and galaxies treated extensively.

Details are included of interesting projects which the new observer could try, such as observing nearby stars and occasional eclipses.

A full range of telescope accessories and detectors is also included together with advice on their use. A 40 page appendix contains additional practical information which should also help owners of this type of telescope to derive the maximum enjoyment from using it. However, the book is not just an instruction manual: it includes some good advice on how to avoid blunders and mistakes in using the instrument.

The Making of a Soviet Scientist

R.Z. Sagdeev, John Wiley & Sons Ltd., Baffins Lane, Chichester, W. Sussex, PO19 1UD, 1994, 339pp, £14.95, ISBN 0-471-02031-1.

This memoir does much to unveil the curtain of secrecy which formerly marked Soviet science. The author was the youngest to be elected as a full member of the USSR Academy of Sciences. As Director of the Space Research Institute, he led the joint US-Soviet Apollo-Soyuz mission, the Venera series to Venus and the Soviet probes to Halley's Comet.

Dr Sagdeev grew up in the elite culture of the technical universities. He undertook pioneering work on the behaviour of hot plasma physics in controlled thermonuclear fusion at the be-

ginning of the cold war, a time of fierce competition between east and west in nuclear science and was thus able to observe, at first hand, the inner workings of the USSR's secretive military-industrial complex.

His book exposes, to an extraordinary extent, the way in which the scientific community was used to foster the objectives of the Communist Party and the military establishment. His account of the corruption and hypocrisy of the Brezhnev era, and its impact on Gorbachev, provides an unprecedented portrait. He describes how Gorbachev was deceived about Soviet technical capabilities by his own people, and how the Arms Talks in Geneva were jeopardised as a result.

The result is a scientific memoir full of provocative insights into the events which marked an extraordinary career.

The Sun as a Variable Star: Solar and Stellar Irradiance Variations

J.M. Pap et al, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 355pp, £40, ISBN 0-521-42006-7.

This timely volume clearly illustrates just how variations in the energy output of the Sun affect the Earth's climate, radiative environment and the chemistry of its upper atmosphere. It provides an up-to-date review of observations, theoretical interpretations and empirical and physical models of variations in the energy outputs of the Sun and solar-type stars and, in particular, shows how this is related to magnetic activity on the surface of the star and how long-term modulations are driven by the stellar interior.

These conditions, together, clearly demonstrate the link between changes in the radiative output of the Sun and the Earth's climatic anomalies.

Directory of Russian Space Industry 1994/95

Sevig Press, 6 Rue Bellart, F-75015 Paris, France, 1994, 188pp, 670 FF, ISBN 2-909002-02-0.

This Directory, supported by ESA and endorsed by the Russian Space Agency, provides a wealth of up-to-date and reliable information on the Russian Space Industry. It contains more than 80 in-depth profiles, each of two or three pages, on Russian space firms and organisations. It also contains some useful notes on Russian space terminology,

including a short Russian/English Space Dictionary and a list of common Russian space acronyms.

The volume is an improved and more comprehensive version of the 1994/5 edition. Though of similar layout, its main difference in substance is a significantly increased number of organisations for which detailed information is provided.

Entries are accompanied by maps showing the locations of each organisation described, its full address, details of participation in space programmes and projects, main activities and organisational structure, together with references to its main partners.

Violent Star Formation: From 30 Doradus to QSOs

G. Tenorio-Tagle, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 431pp, £40, ISBN 0-521-47277-6.

Gathered together in this volume are papers which examine the impact of massive stellar associations on their environment via the power of their ionising radiation and mechanical energy, a burning question if ever there was one.

First it examines the formation and evolution of new clusters of stars and explores possible consequences in a wide variety of objects where massive stellar bursts have occurred. It thus presents an alternative model to that which envisages supermassive black holes as the power houses of active galactic nuclei. It analyses the impact of Wolf-Rayet stars, stellar winds and supernovae on their host galaxies and provides evidence of massive superassociations and of supersonic velocity dispersions resulting from photo-ionisation by violent star formation.

This makes it a timely update on aspects of violent star formation in a host of objects, from 30 Doradus (the largest H II region in the Large Magellanic Cloud) to nuclear star bursts and QSOs.

Exploring Space: Voyages in the Solar System and Beyond

W.E. Burrows, Random House, New York, NY 10022, USA, 1990, 502pp, £24.95, ISBN 0-394-56983-0.

This volume, based on numerous taped interviews and meetings, shows how rivalry between superpowers drove lunar and planetary exploration, sometimes with disastrous results. It

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

also describes the sometimes fierce competition between NASA's science and exploration programmes and the shuttle and how the space science community was finally galvanised into action when it realised that the shuttle and political decisions were about to reduce planetary exploration. It tells why NASA's very existence depends on the shuttle and a manned space station, and why many space scientists consider them both wasteful and unnecessary.

Through all the turmoil and political intrigue, however, one spacecraft undertook a twelve-year, 4.4-billion mile grand tour of the outer planets, sending back enough information to fill a Library and using less power than is required to light a refrigerator bulb. Another fell into the ocean instead of flying to Venus, its projected destination, for lack of a hyphen in its computer program. Still another circled Mars, watching as two hapless Soviet probes, unable to avoid landing, disappeared in a raging dust storm that consumed them. The most sophisticated planetary explorer of them all landed on Mars in 1976 to search for life, with the results of that mission still hotly debated by scientists setting out the basis for a return to the enigmatic red planet, perhaps by humans.

This is an exciting story which ends with some useful appendices providing additional interesting information.

The Quest for Comets: An Explosive Trail of Beauty and Danger

D.H. Levy, Plenum Publishing Co Ltd., 88/90 Middlesex Street, London, E1 7EZ, 1994, 280pp, £19.16, ISBN 0-306-44651-0.

The appearance of bright spectacular comets has inspired fear, wonder and awe since the dawn of human history. Often brighter than stars and moving and disappearing in their own singular orbits, comets have been among the most mysterious objects in the sky, eluding understanding until quite recently.

Nowadays, with the aid of space probes, scientists have discovered that these swiftly-moving chunks of ice and carbon are more plentiful and far more dangerous than previously thought. The role played by comets in the development of the Earth and solar system history is also something only recently realised.

Comets undoubtedly impacted the Earth long ago and may have carried materials necessary to lay the foundations for life. There is also evidence of later comet collisions, one of which may have brought about the demise of the dinosaurs.

The author, a co-discoverer of Comet Shoemaker-Levy 9 which impacted Jupiter earlier this year, describes in detail the thrilling yet often devastating effects of comet collisions.

The second aspect of the book

is a first-hand account of comet hunting, an art in which the author excels and which few have matched. He has already discovered 19 comets, seven of them with a telescope in his own backyard and is now credited with the fourth largest number of comet discoveries since records began.

Hypersonic Flow

M. Rasmussen, John Wiley & Sons Ltd., Baffins Lane, Chichester, West Sussex, PO19 1UD, 1994, 639pp, £62, ISBN 0-471-51102-1.

Hypersonic-flow theory (which concerns flight at speeds much greater than the speed of sound) experienced dramatic development with the advent of the space age and the emergence of the engineering possibilities of transatmospheric flight, hypersonic transports and aerospace planes, with an additional facet provided when the digital computer spawned what is now commonly called computational fluid dynamics.

This book is intended as a text for graduate courses on hypersonic flow so readers, generally, should already possess a background in basic courses of fluid dynamics and gas dynamics. However, advanced undergraduates should also be able to handle the subject-matter and enough detail has been included to enable the text to be used for self-study as well by those working in the fields of high-speed

flow in industry and elsewhere.

The matters covered are broad-based, starting from basic concepts and progressing towards complicated topics and sophisticated methods of analysis.

The Farthest Things in the Universe

J.M. Pasachoff *et al.*, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 104pp, £19.95 Hardback, £11.95 Paperback, ISBN 0-521-46931-7.

Observations penetrating deeper and deeper into space reveal the most distant and powerful objects known and reach back to the earliest stages in the formation of the Universe, soon after its birth in the Big Bang. This book is a survey intended to allow the general reader to share in this exciting astronomical research.

Four recognised experts describe the challenges posed in studying the Universe at its largest scale. They address fundamental questions such as how the Universe is measured, what do the remnants of the primordial background radiation signify about conditions soon after the Big Bang, what are and how can we use quasars to study these early stages in the formation of the Universe and, indeed, how far back in time must we look to see galaxies actually being born?

Two Important Reference Volumes

The RAE Table of Earth Satellites, 1957-1989

1056 pages, published in 1990. Original price £95.

The Society has acquired a stock of the RAE Table of Earth Satellites, a substantial volume originally published at £95 which it is now making available to members at the incredible price of £7.50 (US\$15), plus £4.50 postage and packing in the UK. £9 (US\$16) abroad.

The RAE specialised in the analysis of satellite orbits to determine the Earth's upper atmosphere density and winds, as well as its gravitational field. In order to choose suitable satellites, a listing was necessary, thus leading, over the years, to the present volume containing data on more than 17,000 satellites, including fragments, in 893 pages of tabulation. Extensive revisions have been made to this, the fourth edition, to include not only all new launchings to extend the period covered to 1989 but also to incorporate over 1,000 revisions to the earlier data.

DRA Table of Space Vehicles, 1958-1991

The Society has also acquired the remaining stock of the DRA Table of Earth Satellites, originally published for £30 and now available from the Society at £5 (US\$10) post free.

This is a companion volume to the Earth Satellite Table runs to 113 pp and lists all 124 space vehicles to escape from the Earth over the 1958-1991 period. Data features the name and international designation of each spacecraft and its associated rocket(s), launch date, mass, shape and size and details of orbit or trajectory. Where appropriate the time and place of impact or landing on the Moon or planet are given.

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A Man on the Moon: The Voyages of the Apollo Astronauts

A. Chaikin, Penguin USA, 375 Hudson Street, New York, NY 10014, USA, 1994, 670pp, \$27.95, ISBN 0-670-81446-6.

The lunar landing of Apollo 11 on July 20 1969 brought the 60s to an end on a high note, though the exultation of this "one Giant Leap" has since been muted by the appearance of social-economic problems which have caused governments to look to matters closer to hand.

The author has based his book on hundreds of hours of in-depth interviews with each of the 24 lunar voyagers, as well as those who contributed their talents on Earth. Every aspect of the Apollo Mission is described from the rush to lift-off on top of a Saturn V rocket to the touch-down on the Moon and the final re-entry hurdle.

There is a full account of the intense competition for a seat on a Moonlight as the Apollo Missions unfold from their tragic beginning, the Apollo 204 fire that killed the three Apollo 1 crew on a ground test in 1967, to its spectacular conclusion among the lunar craters.

This is an account of a unique experience shared only by a small band of men who ventured to the edge of human experience and is told as a "warts and all" account, which ranks it as one of the very best publications ever to appear on Apollo.

Detection of Light from the Ultraviolet to the Submillimeter

G.H. Rieke, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994, 344pp, £35, ISBN 0-521-41028-2.

Amazingly rapid progress has been made over the past decade in the development of detectors for use at low light levels in the ultraviolet down to the submillimeter. These advances have not hitherto been presented in a unified manner and, as most texts on the general subject are now a decade or so old, they omit many new areas likely to grow in importance.

The book approaches the subject from the perspective of the underlying physics of the various detector types, with emphasis on the physical limits of detector performance and the physical grounds for choices of design. It begins with a short review of foundation material and then quickly proceeds to a discussion of detectors in general, with the complexity of the concepts growing as the book proceeds. Brief discussions of

current performance levels are included as illustrations only.

Each detector type is introduced with a short paragraph which discusses it in general terms and is followed by a chapter section which emphasises important aspects of its performance.

The volume's up to date review of all the techniques available for the detection of light examines modern detector systems in a way suited to final year undergraduate and graduate students. It will also provide valuable reference material for professionals in astronomy, engineering and physics.

Civil Space Systems: Implications for International Security

S.E. Doyle, Dartmouth, Ashgate Publishing Ltd., Gower House, Croft Road, Aldershot, Hampshire, GU11 3HR, 1994, 271pp, £35, ISBN 1-85521-431-8.

Much of today's astronomical literature focuses on individual aspects of the technology involved, e.g. its use in communications by satellite, launch services, remote sensing, etc. Relatively few attempt to examine the full range of technologies and systems as inter-dependent factors, or to judge their implications from the point of view of international security.

As the utilisation of space expands, its civil and commercial potential appears with competitive services emerging for space launching, communications and other areas.

In the past, the development and use of space technology for both civil and military applications often occurred in parallel, for many space systems, by their very nature, provide information or services suited for both types of usage leading to the result that civil applications also involve important security implications.

The aim in this book is to examine the security implications derived from the increasing number of civil space applications. On the one hand, as the author points out, the expanding use of space encourages greater cooperation among nations, particularly in view of the costs involved but, conversely, some aspects of civil space increase pressures on world security, such as the proliferation of launch vehicles which can be converted to weapon delivery systems. Pressures also arise from the use of space nuclear power sources which may threaten the environment and from manipulation of various kinds of space-broadcast information arrangements. It is suggested that some two-thirds of all basic astronautics technologies are prone to dual

use.

How all these things are used becomes a subject of control by the decision-makers in various countries, and forms the main theme of this book. Considered are the implications of space systems from the point of view of military, political, environmental and economic security, as well as their social and cultural aspects - all fundamental dimensions of international security.

Life Support & Biospherics: Fundamentals, Technologies, Applications

P. Eckart, Herbert Utz Publishers, Schleissheimer Strasse 181c, 80797 Munchen, Germany, 1994, 450pp, US\$118, ISBN 3-9803925-9-7.

This work summarises basic data on the history, requirements and components of life support systems, besides discussing their links with biosphere research.

Life support systems, as currently used in manned space flight, are really mechanically controlled "storage systems" as, for the most part, supplies such as oxygen and food are produced on Earth and stored on-board, not regenerated. Waste products also are stored, not regenerated. Fully regenerative systems will be essential for long-duration space flight so this summary of what is currently known about them is most timely.

The book begins with a study of the Earth's biosphere viz its major physical and ecological characteristics. This is followed by a similar examination of the extraterrestrial environment, including those peculiar to the Moon and Mars.

The next main area of discussion, which relates to the fundamentals of life support systems, is developed further by an examination of physico-chemical life support sub-systems.

Of particular interest is the text relating to bioregenerative life support concepts, for which algae and similar microorgan-

isms have been postulated as necessary because they can carry out their life processes independently of other cells, added to which is the fact that many micro-organisms are already known to exist in extreme environments.

Overall, the book provides a very concise and pleasing summary of what is known and what is needed for the further development of life support systems. The presentation is clear, brisk and encompasses a mine of information in a handy reference form.

Space Discovery and Exploration

Eds M.J. Collins and S.K. Kraemer, Smithsonian Institution, National Air and Space Museum, Gazette Book Services Ltd., Falcon House, Queen Square, Lancaster, LA1 1RN, 1993, 320pp, £45 ISBN 0-38363-893-2.

This is a large coffee-table type of book written by a team of historians and journalists and containing over 160 spectacular colour illustrations. It traces the development of the American Space Programme from its beginnings in the post-war period, through the exciting days of the Apollo Lunar landings and to the crisis which followed the Challenger explosion. Many of the illustrations have appeared elsewhere but the selection is extremely broad and augmented by a number which one would not normally expect to find in a space-related volume.

Decisions affecting the development of America's Space Programme had their base in the realities of the Cold War as the contest for military superiority expanded beyond the Earth's boundaries, thus leading to the growth of an enormous American aerospace involvement.

Particularly interesting are the two final sections in the book which describe the backgrounds to NASA's relationships with the media and the politics of America in space, respectively. Both are excellent and are sure to provide ample food for thought.

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SPACE BOOKS, journals, magazines, newsletters, FREE lists. Geoffrey Falworth, 15 Whitefield Road, Penwortham, Preston PR1 0XJ. Book Tokens welcome.

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INVITATION TO ATTEND RUSSIAN LAUNCH OF (FIRST) AMERICAN ASTRONAUT from BAIKONUR (MARCH 1995)

Those wishing to attend launch of first American astronaut from Baikonur, the Russian "Cape Canaveral", March 14, 1995, are requested to contact THE (Russian) COSMOS CENTER, Washington DC, to receive an **OFFICIAL INVITATION**.

COSMOS "AMERICAN" LAUNCH TOUR PROGRAM (March 11-18, 1995)

Tour Cost is \$2,990 FOB Moscow. Tour/Program begins March 11th in Moscow. Round-Trip Airfare from New York is \$700. USA departure from New York will be at 5 p.m. on the 10th and return departure from Moscow will be at noon on the 18th (arriving JFK/NY at 4 p.m. on the 18th).

MARCH BASIC ITINERARY "HIGHLIGHTS"

- 11 SAT: Arrive Moscow • City Tour • Welcoming Banquet
- 12 SUN: Cultural Tours • Red Square; Kremlin; Museums: (+)
- 13 MON: Fly to Baikonur (The CIS/Russian "Cape Canaveral")
Tours of Space Facilities • Welcoming Banquet.
- 14 TUE: Tours of Space Facilities • Attend Pre-Launch Ceremonies

LAUNCH OF (FIRST) AMERICAN ASTRONAUT from BAIKONUR

More Tours of Space Facilities • Celebration Banquet

- 15 WED: Tours • Fly to Moscow • Cultural/Evening Events
- 16 THU: Tour of Control Center • Attend "live" Docking and Crawl-through of
American astronaut and cosmonauts to the Mir space station.
Tours of THE Space Museum • Attend Circus in Evening
- 17 FRI: Tours of Star City (Cosmonaut Training Center) •
Tours of THE Aviation Museum •
Tours of Mir Space Station manufacturing facilities • Farewell Banquet.
- 18 SAT: Departures OR "ADD-ON-TOURS" (Write for more INFO)

COSMONAUT TRAINING PROGRAM (March 18-25, 1995)

COSMONAUT TRAINING (begins March 18th) is one of several **ADD-ON PROGRAMS**. Cultural Programs (including tours to St. Petersburg and/or Almaty, Kazakhstan) also begin on 18th. **ADD-ON PROGRAMS** can also be arranged prior to March 11, 1995
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Return to the Moon Society Publishes New Studies

Manned exploration of the Moon was very much to the fore in 1994 with the 25th anniversary of the first of the Apollo landings. *Spaceflight* marked the event in its July issue and the Society held meetings attended by many who had played a part in the Apollo Program, notably Buzz Aldrin, who was the second man to set foot on the Moon.

When the Apollo program came to an end in 1972, space exploration became inward looking and the prospect of exploring and developing new worlds such as the Moon and Mars receded into the unforeseeable future.

Now, 25 years on, serious efforts are underway to make that future less unforeseeable. Recent examples are the Clementine mission (*Spaceflight*, September 1994, p.309) and the first International Lunar Workshop organised by the European Space Agency (ESA) and Switzerland (*Spaceflight*, August 1994, p. 254). For Europe, important policy matters come up for review and decision in September 1995 at the ESA ministers' meeting at which account will be taken of Europe's enhanced launch capability in the form of Ariane 5.

Against this background, the Society has been actively involved with those researching the issues that need to be addressed for a successful 'Return to the Moon'. The outcome of what has been a considerable Society effort is the publication of three issues of *JBIS* in December 1994, January 1995 and February 1995 on a range of pertinent subjects. The titles of these

issues are:

- Lunar Industrialisation and Colonization
- Lunar Structures
- Lunar-Based Astronomy.

Details of their contents appear monthly in the corresponding issues of *Spaceflight* in the usual way. (See p.36). All members whose subscriptions include *JBIS* will receive these issues.

Special Three-Issue Subscription

For the convenience of those wishing to obtain the December 1994 - February 1995 issues of *JBIS*, a combined subscription may be entered as follows:

For members: £15.00 (\$27)
For non-members: £52.50 (\$96)

Please send to:

The British Interplanetary Society,
27/29 South Lambeth Road,
London SW8 1SZ

enclosing the appropriate remittance.

Arthur C. Clarke TV Documentary

In early November, the Society's Offices were "hijacked" by an 11-man team for the purpose of collecting material for a TV Documentary to be made for Japanese Television on the Life and Work of Arthur C. Clarke. They sought out interesting material from our records in connection with Arthur, including an original copy of his *Wireless World* article entitled "Extra-terrestrial Relays". Film was taken of pictures and artifacts throughout the building and an interview was given by Len Carter on Arthur's long association with the Society, particularly in its early years. Also featured will be the audience and speaker at one of our Evening Lectures that was being held at the time on the subject of the Chinese Space Programme.

It is understood that two versions of the edited film (one a news shot) are to be screened in Japan in January 1995.

Membership Renewal

Many 1995 Membership Renewal forms have now been returned to the Society and our thanks go to all concerned for their prompt response. Work at HQ is now increasingly geared to the Society's 1995 programme and publications, and those who have not yet renewed are urged to do so without delay, both to give support to this work and to ensure that they continue to receive their magazines on a regular basis.

The Society now has an E-Mail address. It is ble@cix.compulink.co.uk.

'Shuttle Acronyms' Competition

Acronyms can be a great aid in communicating technical matters - provided the recipient is familiar with the acronym already. STS for Space Transportation System can hardly present a problem for anyone familiar with the US space shuttle programme. But others, that are not in such regular use, may not be immediately recognised and offer a basis for this month's competition - and an opportunity for readers to win a prize.

Prizes: The first four correct entries to be opened after the closing date of 2 February 1995 will receive a copy of the video

STS-58: Mission Highlights

This video covers the "Third time lucky" launch of Columbia on 18 October 1993 into its record-breaking 14-day flight during which the crew of seven conducted studies with the Spacelab Life Sciences 2 Module.

To Enter: Write down what the following acronyms stand for. They all have a shuttle connection and have at some time appeared in *Spaceflight*.

1. LAGEOS
2. LITE
3. OPF
4. PILOT
5. SAREX
6. UARS

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 2 February 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

* Tapes are VHS PAL format only and are not compatible with the US NTSC system.

Title/Name

Address

Orion's Planets-To-Be

New Hubble images clearly reveal the presence of disks of dust - the raw material for planet formation - around at least half and probably many more of the stars in the Orion Nebula, a region only 1,500 light-years from Earth where new stars are being formed. A survey of 110 stars found disks around 56 of them.

Before the Hubble discovery, remnant dust disks had been confirmed around only four stars: Beta Pictoris, Alpha Lyrae, Alpha Piscis Austrini and Epsilon Eridani. They are a fraction of the mass of those in Orion and might be leftover material from the planet formation process. Unlike these previous observations, Hubble has observed newly formed stars less than a million years old which are still contracting out of primordial gas.

Hubble's resolution has allowed an accurate determination of the mass of the outer rim of a dark elliptical disk silhouetted against the bright background of the Orion Nebula. It turns out to be at least several times the mass of the Earth. The entire disk is 53 billion miles across, or 7.5 times the diameter of the Solar System. The central, reddish star is about one fifth the mass of the Sun. The findings of an abundance of protoplanetary disks in a cluster of young stars reinforces the assumption that planetary systems are common in the universe.

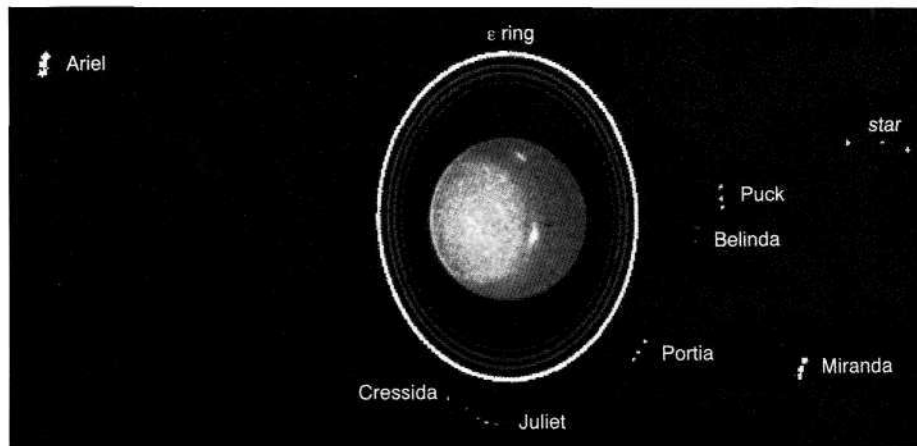
The Orion results, obtained by Dr. C. Robert O'Dell, are to appear in the 20 November issue of the *Astrophysical Journal*.

Telescope Benefits from Technology Advances

On 11 October the first images of astronomical objects were achieved by the new high-tech 3.5 m telescope at Kitt Peak National Observatory, Arizona. The telescope is the product of a collaboration between the Tucson-based National Optical Astronomy Observatories, the University of Wisconsin, Indiana University and Yale University. The telescope is based on recent advances in telescope technology and, if it performs as planned, parts of it may be copied in the design of future larger telescopes. A remote observing capability will allow astronomers at each university to use the telescope at their own locations.

The telescope has a wide field of view with an instrument that uses fibre optics to let observers analyse many astronomical objects at once by assigning each object in the field of view to a different optical fibre. This allows the telescope to perform like 100 conventional telescopes of the same size at the same time with optimum image quality. Some of the research planned by Indiana University concerns:

- Surveying clusters of galaxies to test theories about their formation and evolution;
- Observing unusual pairs of stars that contain highly collapsed white dwarf stars, neutron stars or black holes;
- Observing Saturn's rings next year when the Earth and Sun will pass through the plane of the rings; and
- Studying how frequently pairs of stars are created in the star-forming regions of the Milky Way.



Uranus, Rings and Satellites

Hubble's new image of Uranus was obtained on 14 August when the planet was 2.8 billion km from Earth. Similar details of its moons, rings and atmosphere were only previously seen by the Voyager 2 spacecraft that flew by Uranus in 1986. The rings were discovered by stellar occultation experiments in 1977, but not seen directly until Voyager flew to Uranus.

Each of the inner moons appears as a string of three dots in this picture because it is a composite of three images, taken about six minutes apart. When these images are combined, they show the motion of the moons compared with the sky background. Because the moons move much more rapidly than our own Moon, they change position noticeably over only a few minutes. These multiple images also help to distinguish the moons from stars and imaging detector artifacts, i.e. cosmic rays and electronic noise.

Astronomers will now be able to determine the moons' orbits more precisely and study the unusual dynamics of Uranus' complicated satellite system.

Uranus is largely featureless but HST does reveal a high altitude haze which appears as a bright "cap" above the planet's south pole, along with clouds at southern latitudes (similar structures were observed by Voyager). Unlike Earth, Uranus' south pole points toward the Sun during part of the planet's 84-year orbit and over many years, Hubble will be able to follow seasonal changes in Uranus' atmosphere, which should be unusual due to the planet's large tilt.

KENNETH SEIDELMANN, US NAVAL OBSERVATORY and NASA

Satellite to Observe Starburst Galaxies

Starburst galaxies are galaxies that appear to be undergoing a burst of star formation being vast clouds of molecular gas that are the site of star formation. A new Jet Propulsion Laboratory satellite, selected for flight in 1998 as part of NASA's Small Explorer program, is to study the evolution of such galaxies billions of light-years away and also luminous protogalaxies - or infant galaxies - at much greater distances.

Most of the luminosity from young, hot stars is blocked at optical wavelengths by surrounding dust and molecular gas, but it can be detected at infrared wavelengths. The satellite, called the Wide Field Infrared Explorer (WIRE) will be a cryogenically cooled, 30 cm infrared telescope with no moving parts and a field of view about the size of a full Moon. The instrument will require only 35 watts of power and a low data rate of 9,000 bits per second.

Recent major advances in infrared detector technology will allow the satellite to detect distant galaxies in the 12 to 25 μ m wavelength range. The infrared detectors will be supplied by the Rockwell International Science Center in Anaheim, California and the solid hydrogen cryogenic container will be provided by Lockheed Palo Alto Research Laboratories, California. Using this state-of-the-art technology, WIRE will survey about 100 square degrees of sky during its four-month lifetime and amass a catalog exceeding the size of the existing Infrared Astronomical Satellite (IRAS) Point Source Catalog. The satellite will be able to observe starburst galaxies 500 times

fainter at these wavelengths than those observed by the 1983 IRAS mission.

The telescope will be carried on a three-axis spacecraft bus designed and built by the Small Explorer project team at NASA's Goddard Space Flight Center in Greenbelt, Md and will be launched in October 1998 by a Pegasus XL launch vehicle. It will be placed in a nearly polar orbit 400 km above the Earth and following a Sun-synchronous path in which the Sun will be at the same point in the sky at the same time each day. Such an orbit will simplify other spacecraft requirements, such as being able to use a relatively small, fixed solar array and a small battery to operate the telescope.

Data processing and analysis will be performed at the Infrared Processing and Analysis Laboratory at Caltech. NASA's Small Explorer Program provides frequent flight opportunities for highly focused and relatively inexpensive science missions. WIRE was one of two missions selected by NASA in September 1994 for development as a Small Explorer mission. Design, development and operations of WIRE through the first 30 days of orbit will cost \$50 million.



A view of the Mobile Service Tower (MST) and an assembly mock-up of the Indian-made Polar Satellite Launch Vehicle (PSLV) at the SHAR Centre, Sriharikota.

India's Rocket Propellant Developments

On 15 October 1994, the first successful launch took place of India's four-stage Polar Satellite Launch Vehicle (PSLV) from the Sriharikota launch base (*Spaceflight*, December 1994, p.405). Behind this success lies a long-standing and active programme of Indian rocket propulsion development and propellant production. *Hormuz Mama* provides an overview of this work, particularly in relation to the PSLV.

India's propellant development efforts were concentrated for many years on solids and when India subsequently designed the PSLV to place a 1,000 kg payload into a Sun-synchronous polar orbit, the first and third stages not surprisingly featured solid propellants, an arrangement that is unique among large launch vehicles. The second and fourth stages use storable liquid propellants.

Stages 1 and 3

The PSLV first stage, which has a 128-tonne segmented charge based on a HTPB (hydroxyl-terminated polybutadiene) propellant, is the third-largest solid propellant stage in the world. It is 2.8 m in diameter, has a 96 sec burning time and produces a peak thrust of about 45 tonnes. Incidentally, while stage 1 has a conventional metal motor case of 18% Ni M-250 maraging steel, the third stage (which has the same propellant) has an advanced polyamide (Kevlar) fibre case.

Solid Propellant Production

The HTPB propellant is a formulation with HTPB resin as fuel-binder, ammonium perchlorate as oxidiser and various additives. Even today, HTPB-based propellants are regarded as the most advanced in performance and physical properties. Since the technology for it could not be obtained from abroad, the process for HTPB manufacture had to be developed in house at the Vikram Sarabhai Space Centre. As the Indian Space

BY HORMUZ P. MAMA

Bombay, India

Research Organisation (ISRO) is a purely R & D organisation, the technology was then passed on to a private company, National Organic Chemicals Limited (NOCIL) to produce the resin.

For production of propellant-grade ammonium perchlorate, a very modern plant was set up at Alwaye in South India, again with entirely indigenous technology that was developed at the Central Electro-Chemical Research Institute. The propellant is produced by the double decomposition of sodium perchlorate with ammonium chloride and the plant has a capacity of over 400 tonnes a year. Some years back, when Bristol Aerospace of Canada could not obtain ammonium perchlorate from their usual US source due to a fire at the latter's plant, they obtained it from India. It was used to make solid propellant charges for their sounding rockets.

Stages 2 and 4

PSLV's Stage 2 is based on the French SEP Viking engine employing nitrogen tetroxide (N_2O_4) oxidiser and unsymmetrical dimethyl hydrazine (UDMH) as fuel. Known as the VIKAS, it has a higher propellant load of over 37 tonnes than the Viking engine and a longer burning time of 150 sec. The fully indigenous Stage 4 has virtually the same oxidiser - actually a mixed

oxide of nitrogen (MON-3 consisting of 3% nitric oxide and 97% N_2O_4). The fuel is monomethyl hydrazine (MMH).

Propellant Developments

Even the best solid propellants have a low performance (measured in specific impulse) compared to liquid propellants. To enhance the performance of the HTPB-based propellant, ISRO has developed an advanced formulation that incorporates 20% HMX explosive at a high 88% solids loading on an experimental basis. HMX also helps to suitably modify the burning rate of the propellant formulation. No application is currently planned for it.

The above-mentioned liquid propellants, which are also produced indigenously, are still widely used in the Titan as well as in the Chinese Long March series. Such storable propellants do not have a specific impulse comparable to that of cryogenic combinations like liquid oxygen/liquid hydrogen, and ISRO has recently studied a stable UDMH and kerosene gel containing 30% aluminium powder in suspension to obtain an enhanced performance. No application has yet been planned for it though.

Cryogenic Propellants

While the three-stage Geosynchronous Satellite Launch Vehicle (GSLV), designed to place a 2,500 kg satellite into a geosynchronous transfer orbit, will have the first two stages of the PSLV, the third stage will have liquid oxygen/liquid hydrogen cryogenic propellants. Cryogenics is the science of low temperatures, and these propellants are characterised by very low boiling points, like -252.8°C for liquid hydrogen and -182.98°C for liquid oxygen. While Russia is to supply seven cryogenic propellant engines for third-stage use, India's own 12-tonne thrust C-12 engine is already under development. An integrated liquid hydrogen production plant is already operational at Mahindragiri. The C-12 engine should be operational by the end of 1998.

The GSLV will be used to place India's INSAT-2 series of communications/meteorology satellites into orbit from the Sriharikota launch complex.

'Planetary Probes' Competition Winners

Winners to whom video prizes will shortly be dispatched are:

L.M.O. Passmore	Berkshire, UK
P. Harris	Kent, UK
T. Cools	Bruges, Belgium
K.J. Sullivan	Cambs, UK

The correct answers are: 1. Mariner 10; 2*. Mariner 2 or Venera 1; 3*. Mariner 4 or Mars 1; 4. Pioneer 10; 5. Pioneer 11; 6. Voyager 2; 7. Voyager 2.

*Answers with/without return of data accepted.

Space Station Collaboration

Sir, To get into space faster, safer and cheaper, I would propose the use of the Russian Energiya strap-on booster to upgrade the shuttle's cargo performance.

With such an LRB (liquid rocket booster) the shuttle could lift roughly some 30-40 tons to LEO which could greatly assist station assembly. The LRB's thrust can also be throttled and turned off in emergencies. Also liquids do less harm to the environment than solids. Not only that but the added power to the shuttle system will make shuttle derived HLLV's such as Shuttle C and Shuttle 2 more attractive for station cargo and other missions.

Internationally, use of the Energiya LRB will make great sense because it will help the Russian economy and enable the Energiya system to be brought back on line. This could also play its part in the station's assembly.

When the station is complete, however, what shall we do with it? Its sole function of microgravity research is just not enough. So I suggest:

- Revive the Beam Builder of the 1970s. Attached to either the truss or a node this machine could produce structures that may help to achieve space fabrication. Later on 'teams' of builders could be put to work in space to help produce space colonies and Mars colonist spacecraft using metals mined by robot from the Moon or an asteroid.
 - If the Builder could be revived by an international team this could make it even more attractive.
 - If the 1996 shuttle reflight of a tether system is a success then the station could serve as a test bed for tethers, such as placing a small payload in a higher or lower orbit by a tether attached to its truss section.
- These activities would of course disturb the microgravity environment of the laboratory module and some sort of rota would have to be worked out.

I hope that something like this will be done so that we can have a space station worth 'UNITING' for.

E. PHILPOTT
South Wirral, UK

Designating Astronauts

Sir, I refer to the letter by Mr Holtkamp on p.391 of the November issue of *Spaceflight*.

'The RAE Table of Earth Satellites' has used the designation 1984 034C to identify the second MMU flight. On the other hand, NASA's *Satellite Report* does not recognise this designation and apparently it did not receive a NORAD number. None of the other 'free flying' astronauts received a designation of any sort.

JOS HEYMAN
Riverton, WA
Australia

Soviet Spacesuits

Sir, With reference to *Spaceflight*, August 1994, p.280 and October 1994, p.353, I enclose a picture (below) showing Belyayev/Leonov inside the Voskhod-2 mock-up trainer in their space suits.

Also enclosed is a picture (right) of Komarov taken a few hours before liftoff on board Soyuz-1.

The Voskhod-2 and Soyuz-1 spacesuits look very much the same.

J.K. ANDERSEN
Skagen, Denmark



Microwave Propulsion

Sir, In March 1993, *Spaceflight* featured reusable orbital vehicles. I would like to put forward an idea on that topic.

The HOTOL idea is ingenious in that no (or little) oxidant is carried aloft, but why not leave the fuel behind as well?

Use the air as the propulsive medium and deliver energy to the vehicle by microwave power beams.

There would be two "Power Towers" connected to the grid, capable of producing and directing microwave beams of great power (hundreds of megawatts) and of great intensity.

The vehicle would consist of a main fuselage incorporating payload, receptors and converters. The engines would be ramjets mounted on stubs.

The microwave beam is received at the vehicle and a small proportion converted into electricity which is used to produce:

- Large magnetic fields in the ramjets to form a magnetic containment, and
- A high intensity arc in the incoming air to heat it to plasma temperatures (ignition).

The plasma is contained and passed into the main chamber where the rest of the microwaves are poured into it neat. The plasma strongly absorbs the microwaves and becomes exceedingly hot, exiting via a magnetic nozzle upon which it exerts quality thrust (reheat).

Like any ramjet a separate means of starting must be provided. Once the vehicle is moving, the first tower - the propulsor tower - supplies energy and "pushes" the vehicle upwards to a height of 80 km, when it comes into the line of sight of the second tower - the tractor tower - about 1000 km away.

The second tower then supplies a power beam unobscured by the hot ex-

haust, which enables the vehicle to remain at a height of circa 80 km, while accelerating up to 8000 m/sec in under four minutes at no more than 3.5 g. A final flip puts the vehicle into space.

Thus, orbit is achieved using off-peak electricity. Any comments?

D. BONSALL
Cheshire, UK

The following comments have been sent to us by Alan Bond:

This is a scheme which has been advocated from time to time but which is full of practical problems.

The sheer power levels needed are the main problem, being gigawatts and not "hundreds of megawatts" as quoted in the letter.

The next problem is that of efficiently absorbing the power in the breakdown plasma and mixing in cold air to give efficient thrust.

Electrical equipment also tends to be very heavy resulting in poor overall performance. A limitation of any beamed power system is the ultimate limit it imposes on traffic levels. For example, civil aviation could never operate this way and it is the objective to see spaceplane traffic grow to substantial levels.

Finally the propagation of intense microwave beams in the atmosphere and the safety problems they present are serious, probably unsurmountable, problems. For example, SPS proposals have to limit beam power densities to about 10 mW/cm² and need guard zones around the ground rectenna of several km.

Of course the hypersonic aerodynamic design problems of the vehicle and its intake are in addition to those of the power transmission system.

Deceased Cosmonauts/Astronauts up to May 1993

Sir, I enclose a list of deceased cosmonauts and astronauts that I know about. They are listed in order to their date of death.

Name and Country	Birth/Death Dates	Cause of Death
V.V. Bondarenko (USSR)	16.02.37 23.03.61	Isolation chamber fire
T.C. Freeman (USA)	18.02.30 31.10.64	T-38 Talon trainer plane crash
G.G. Nelyubov (USSR)	31.03.34 18.02.66	Railway accident
E.M. See, Jr (USA)	23.07.27 28.02.66	T-38 trainer plane crash
C.A. Bassett II (USA)	30.12.31 28.02.66	T-38 trainer plane crash
V.I. Grissom (USA)	03.04.26 27.01.67	Apollo 1 fire
E.H. White II (USA)	14.11.30 27.01.67	Apollo 1 fire
R.B. Chaffee (USA)	15.02.35 27.01.67	Apollo 1 fire
V.M. Komarov (USSR)	16.03.27 24.04.67	Soyuz 1 parachute failure
E.G. Givens, Jr (USA)	05.01.30 06.06.67	Volkswagen car crash
R.L. Rogers (USA)	12.04.28 13.09.67	F-105 Thunderchief explosion
C.C. Williams, Jr (USA)	26.09.32 05.10.67	T-38 Talon trainer plane crash
M.J. Adams (USA)	05.05.30 15.11.67	X-15 rocket plane crash
R.H. Lawrence, Jr (USA)	02.10.35 08.12.67	F-104 Starfighter fighter crash
Y.A. Gagarin (USSR)	09.03.34 27.03.68	UTI MiG-15 fighter crash
P.I. Belyayev (USSR)	26.06.25 10.01.70	Complications after surgery
J.M. Taylor (USA)	27.11.30 04.09.70	T-38 trainer plane crash
G.T. Dobrovolski (USSR)	01.06.28 30.06.71	Soyuz 11 depressurisation
V.N. Volkov (USSR)	23.11.35 30.06.71	Soyuz 11 depressurisation
V.I. Patsayev (USSR)	19.06.33 30.06.71	Soyuz 11 depressurisation
V.N. Benderov (USSR)	04.08.24 03.06.73	Tu-144 supersonic liner crash
V.D. Shcheglov (USSR)	09.04.40 19.07.73	Cancer
A.V. Sorokin (USSR)	30.03.31 23.01.76	Leukaemia
O.G. Kononenko (USSR)	16.08.38 08.09.80	Yak-38 VTOL plane crash
V.S. Varlamov (USSR)	15.08.34 02.10.80	Haemorrhage of the brain
L.G. Ivanov (USSR)	25.06.50 24.10.80	MiG-27 attack plane crash
Bui Thanh Liem (Vietnam)	30.06.49 ??-09.81	UTI MiG-21 fighter crash
J.L. Swigert, Jr (USA)	20.08.31 27.12.82	Cancer
F.R. Scobee (USA)	19.05.39 28.01.86	Shuttle Challenger explosion
M.J. Smith (USA)	30.04.45 28.01.86	Shuttle Challenger explosion
E.S. Onizuka (USA)	24.06.46 28.01.86	Shuttle Challenger explosion
J.A. Resnik (USA)	05.04.49 28.01.86	Shuttle Challenger explosion
R.E. McNair (USA)	21.10.50 28.01.86	Shuttle Challenger explosion
G.B. Jarvis (USA)	24.08.44 28.01.86	Shuttle Challenger explosion
S.C. McAuliffe (USA)	02.09.48 28.01.86	Shuttle Challenger explosion
S.N. Anokhin (USSR)	19.03.10 15.04.86	?
S.D. Thorne (USA)	11.02.53 24.05.86	Pitts A-2 aerobatic plane crash
D.F. Eisele (USA)	23.06.30 02.12.87	Heart attack
A.S. Levchenko (USSR)	21.05.41 06.08.88	Brain tumour
A.V. Shchukin (USSR)	19.01.46 18.08.88	Su-26 aerobatic plane crash
S.D. Griggs (USA)	07.09.39 17.06.89	AT-6D Harvard plane crash
J.W. Wood (USA)	19.08.24 01.01.90	?
R.E. Evans (USA)	10.11.33 07.04.90	Heart attack
V.I. Gulyayev (USSR)	31.05.38 19.04.90	Chronic disease
O.A. Yakovlev (USSR)	31.12.40 02.05.90	Heart attack
R.A. Stankovich (USSR)	26.07.44 09.09.90	Su-27 fighter crash
V.I. Filatyev (USSR)	21.01.30 15.09.90	Cancer
V.G. Lazarev (USSR)	23.02.28 31.12.90	Accident
M.L. Carter, Jr (USA)	15.08.47 05.04.91	EMB-120 airliner crash
J.B. Irwin (USA)	17.03.30 08.08.91	Heart attack
V.A. Grishchenko (USSR)	26.04.42 04.05.92	Suicide
I.N. Anikeev (USSR)	12.02.33 20.08.92	Cancer
A.Y. Petrushenko (Russia)	01.01.42 11.11.92	Cancer
S.A. Yemelyanov (Russia)	03.03.51 05.12.92	Heart attack

Deceased X-15 Rocket Plane Pilots

I.C. Kincheloe, Jr (USA)	02.07.28 26.07.58	F-104 Starfighter fighter crash
J.A. Walker (USA)	20.02.21 08.06.66	F-104/XB-70A mid-air collision
M.J. Adams (USA)	see above	
J.B. McKay (USA)	08.12.22 27.04.75	Complications after X-15 crash
F.S. Petersen (USA)	16.05.22 08.12.90	?
R.A. Rushworth (USA)	09.10.24. ??-??-93	?

I would be grateful to everybody who can help to remove the question marks.

VADIM Y. MOLCHANOV
Tula, Russia



Boris Yegorov

Cosmonaut Yegorov Dies

Sir, Boris Borisovich Yegorov, a medical doctor who participated in the first three-man flight in the Voskhod spaceship on 12-13 October 1964, unexpectedly died at his home in Moscow on 12 September of a heart attack at the age of 56.

Boris Yegorov was born in Moscow on 26 November 1937. In 1955 he enrolled at the Sechenov First Moscow Medical Institute and during the last two years of his study he worked part-time at the Central Institute for Aviation Medicine, where the first military candidate-cosmonauts were being tested medically and psychologically.

In 1961 he went to work full time at this institute and, after having become an amateur-parachutist, he was assigned to one of the recovery teams for Vostok-1, Gagarin's flight.

In May 1964, at the initiative of chief designer Sergei Korolyov he was accepted as a cosmonaut trainee for the first flight in a multi-seater spacecraft, Voskhod-1.

With Vladimir Komarov as commander and Konstantin Feoktistov as flight engineer he was launched aboard the Voskhod on 12 October 1964 and during the one-day flight he did medical research on his fellow crewmen. Vladimir Komarov later perished during the Soyuz-1 flight in April 1967. Feoktistov, a spacecraft designer, has retired and lives in Moscow.

Yegorov joined the Institute of Biomedical Problems in 1964. He became a doctor of medicine in 1979 and later he worked as a professor and head of the Biomedical Technology Institute of the Ministry of Health.

Like many former cosmonauts he recently tried to make a living in private business. During the 1993 Moscow coup he experienced a severe personal tragedy when the 20 year old son of his second wife, a student of medicine, died during the shoot-out near the Ostankino TV centre.

PETER SMOLDERS FBIS
The Netherlands

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Deceased Cosmonauts

Sir, My friend, Sergei Voevodin, of Kosroma in Russia, has compiled a list of the 227 known men and women selected as cosmonauts in the Soviet/Russian space programmes. The most extraordinary aspect of this list to me is that no fewer than 28 of the men selected have died.

Some, such as Yuri Gagarin, Komarov and the three men who died in the June 1971, Soyuz disaster, are known to have died in accidents, either in space or on Earth. The oldest to die was Sergei Anokhin, who was 76 when he died in 1986, 20 years after he had been selected, and the youngest was Valentin Bondarenko, who died in 1961 at the age of 24. Neither took part in a space mission.

The average age of death of these men was just under 46. It is known that the death rates for middle aged men in the former Soviet Union are higher than those in the West, perhaps because they smoke more cigarettes and eat a less healthy diet. But a rate of attrition of over 12 per cent of a presumably healthier than average group raises some questions. Only a

handful of US astronauts have died in the same period - some of them in accidents - and it seems likely that at least some of the cosmonauts casualties have been due to accidents during training.

One cosmonaut was in his twenties when he died, six were in their thirties, 11 in their forties, seven in their fifties, two in their sixties and one in his seventies. It seems that being a cosmonaut is quite a dangerous occupation, although there is no suggestion that exposure to space contributed to the deaths, except in the cases of Komarov, Patsayev, Dobrovolsky and Volkov.

ARTHUR E. SMITH
Bath, UK

Ed: Information on the cause of death of cosmonauts up to May 1993 appears in the letter opposite from Vadim Y. Molchanov. A list given by Arthur Smith in his letter (but not reproduced here) includes the more recent death of Vladimir Yevgeniyevich Preobrazhensky on 25 October 1993 at the age of 54.

Writer's Success

Sir, I would like to let you know of my success in the "Young Science Writers" essay competition organised by the Irish Times paper.

I won third place writing on the subject of the search for black holes. I found *Spaceflight* magazine extremely helpful in researching the subject and wish to congratulate you on the publication.

CATHAL HOARE
Co. Cork
Eire

Buran

Sir, I was in Moscow recently and saw the sad sight of the flight worthy Buran airframe in Gorky Park (*Spaceflight*, July 1994, p.249).

Unfortunately M.Q. Hassan's comment (November 1994, p.392) that the Cosmos Pavilion would be a far more fitting resting place is a bit premature as the pride of Space Museums worldwide has been transformed into a car showroom.

TED EDWARDS FBIS
Manchester, UK

Animals in Space

Sir, With reference to Carl Rigg's letter (*Spaceflight*, November 1994, p.393), I am able to clarify the corresponding French experiments.

In continuing its extensive space activities which started at the end of the 1940s, France became the third nation in the world to launch animals into space. Liquid propellant rockets, because of their lower acceleration compared to solid ones, were selected from the Veronique family.

The first series of launches (rats and cats) were made with Veronique AGI (for Année Géophysique Internationale). A later series with monkeys used the bigger Vesta version. The success rate was rather good, with two failures/partial failures out of six flights.

Date	Rocket	Animal	Result
22/2/61	AGI 24	Hector rat	OK
15/10/62	AGI 37	Rat	OK
18/10/62	AGI 36	Rat	Recovery failure
18/10/63	AGI 47	Félicette cat	OK
24/10/63	AGI 50	Cat	Failure
7/3/67	Vesta 04	Martine monkey	OK
13/3/67	Vesta 05	Pierrette monkey	OK

At the head of these experiments was Médecin Général Grandpierre, Director of the CEMA (Centre d'Etudes et de Recherches de Médecine Aéronautique).

P. JUNG
Grasse
France

Spaceflight Crossword

No. 17

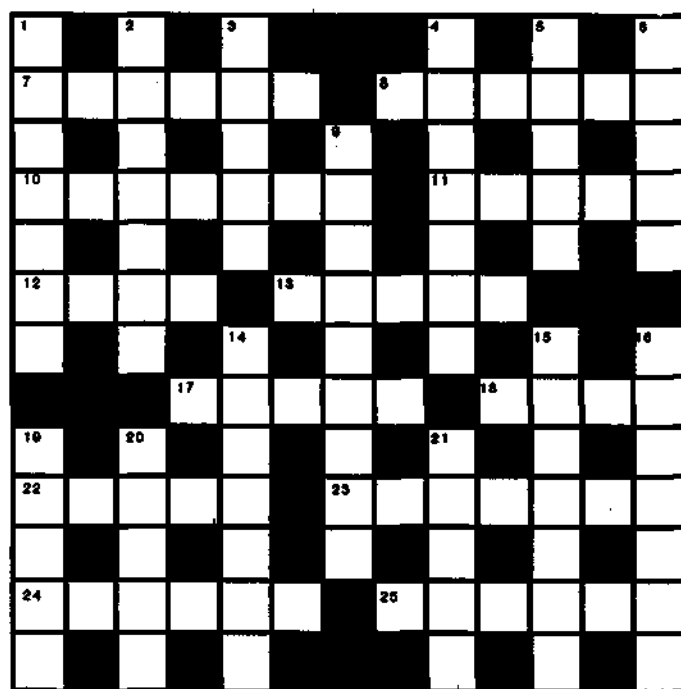
ACROSS

7. Predominant
8. Fasten
10. Astronaut's task
11. Main, as for the selected crew
12. Single item of equipment with specific function
13. State of the USA
17. Slice meat
18. Favourable type of weather for a launch
22. Feature of Saturn
23. Made into one
24. Pertaining to a tide when Sun and Moon pull together
25. Stick

DOWN

1. Belgian Astronaut
2. Pertaining to sedimentary rock composed of fragments of older rock
3. Asian country active in space
4. Temporary substitute (4-3)
5. Syrian cosmonaut
6. Large piece of paper
9. Orbiter
14. Space probe to be launched to Saturn
15. Space probe to Jupiter
16. Astronomer who discovered the aberration of light
19. — national product
20. Below
21. Turns

Solution will appear in the February issue.



Solution to Crossword No.16.

ACROSS: 1. Solar; 4. Minimum; 8. Hoffman; 9. Vesta; 10. Insat; 11. Element; 13. Eddy; 15. Tundra; 17. Replay; 20. Rear; 22. Reports; 24. Risks; 26. Count; 27. Octaval; 28. Precept; 29. Canon.

DOWN: 1. Schmidt; 2. Lifts; 3. Remoter; 4. Manned; 5. Novae; 6. Misdal; 7. Meant; 12. Lyra; 14. Dart; Neptune; 18. Erratic; 19. Ypsilon; 21. Escort; 22. Recap; 23. Retie; 25. Seven.

SATELLITE DIGEST-272

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Philip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Design	Launch	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Soyuz-TM 20	1994-063A	Oct 3.95	Tyuratam	Soyuz	7,150 ?	Oct 16.20	51.65	92.46	393	397	[1]
INTELSAT 703	1994-064A	Oct 7.27	ER	Atlas-2AS	3,720	Oct 15.54	0.24	1,436.52	35,662	35,928	[2]
Solidaridad 2	1994-065A	Oct 8.05	Kourou	Ariane 44L	2,776	Oct 27.48	0.22	1,436.05	35,772	35,794	[3]
THAICOM 2	1994-065B				1,080	Nov 3.89	0.04	1,436.24	35,698	35,881	[4]
Okean 4	1994-066A	Oct 11.60	Plesetsk	Tsyklon	1,900 ?	Oct 12.27	82.55	97.70	632	666	[5]
Ekspres 1	1994-067A	Oct 13.68	Tyuratam	Proton-4	2,500 ?	Oct 31.37	0.21	1,436.39	35,777	35,808	[6]
IRS P2	1994-068A	Oct 15.21	Srihankota	PSLV	804	Oct 16.24	98.69	101.74	798	883	[7]
Elektro 1	1994-069A	Oct 31.60	Tyuratam	Proton-4	2,400 ?	Nov 1.51	1.30	1,441.21	35,851	35,922	[8]

NOTES

- Spacecraft carrying three crew members: A.S. Viktorenko (commander), Y.V. Kondakova (flight engineer) and U. Merbold (German cosmonaut on a commercial mission for the European Space Agency). Docked with the Mir Complex 1994 October 6.02. Viktorenko and Kondakova are due to remain in orbit until March 1995 (with V.V. Polyakov, launched aboard Soyuz-TM 18), Kondakova completing the longest flight by a woman; Merbold returned aboard Soyuz-TM 19 in early November 1994.
- Communications satellite, built by Space Systems/Loral for INTELSAT. Satellite initially located over 121 °E.
- Solidaridad 2 is a communications (telephone, TV, data relay and mobile services) satellite, operated by Telecomunicaciones de Mexico. Located over 247 °E.
- Thaicom 2 is a telecommunications satellite (including data relay and voice transmission), operated by Shinawatra Satellite Public Co Ltd (Bangkok). Initially located over 85 °E, but to be operated over 78.5 °E.
- Eighth Okean-O satellite to be launched, the first four flights being within the Cosmos programme (Cosmos 1500, 1602, 1768 and 1869). All-weather oceanographic satellite, carrying a 1.5 km resolution radar, visual and infra-red sensors and a radiometer.
- First flight of new-generation communications satellite, planned to replace Gorizont satellites. Stationed over 70 °E.
- First successful launch of India's PSLV (Polar Satellite Launch Vehicle), placed IRS (Indian Remote Sensing) payload into orbit. Previous flight of PSLV on 1993 September 20.

- First flight of long-promised satellite to inaugurate the GOMS (Geostationary Operational Meteorological Satellite) programme announced in 1975. Elektro still drifting to its planned location in early November 1994.

ADDITIONS AND UPDATES

- 1993-018A Cosmos 2238 was manoeuvred off-station and retired from operations on 1994 September 21. Add the following orbital data (the first orbit is its operational one):- 1994 September 20.95, 65.02°, 92.78 minutes, 403 km, 419 km 1994 September 21.39, 65.02°, 90.94 minutes, 228 km, 414 km
- 1994-037A FSW-2 2 equipment module decayed from orbit September 13.
- 1994-042A Cosmos 2283 was recovered approximately September 29.8.
- 1994-052A Progress-M 24 undocked from the Mir Complex 1994 Oct 4.79 and was de-orbited October 4.91.
- 1994-059A Discovery (STS-64) returned to Earth September 20.88: the landing date was incorrectly quoted previously, but the time was correctly given.
- 1994-059B SPARTAN 201 returned to Earth 1994 September 20.88: the landing date was incorrectly quoted previously, but the time was correctly given.
- 1994-062A Add the following orbital data for Endeavour (STS-68):- 1994 October 7.67, 58.99°, 88.81 minutes, 199 km, 212 km. The shuttle landed at Edwards Air Force Base 1994 October 11.71.

JBIS



An expanded January 1995 issue of the *Journal of the British Interplanetary Society* is now available. It features the second of our series of studies entitled "Return to the Moon" with the following papers on the theme of:

Lunar Structures

- Lunar Bases of the 20th Century: What Might Have Been
- Lunar Base System Design
- Manned Lunar Base Selection

Lunar Base Infrastructure and Lunar Resources (Lunar Cargo Shuttle Using Lunar Propellant)

- Thermal Control on the Lunar Surface
- Inflatable Structures for a Lunar Base
- Considerations of a Habitat Design
- Lunar Soil Mechanics
- Mobile Lunar Base Project

A Commercial Lunar Helium 3 Fusion Power Infrastructure

Copies of JBIS, priced at \$5.00 (US\$9.00) to members, \$17.50 (US\$32.00) to non-members, post included, can be obtained from the address below. Back issues are also available.

The British Interplanetary Society
27/29 South Lambeth Road
London SW8 1SZ
England.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a fee for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

1 February 1995 7 - 8.30 pm

Great Balls of Ice - The Satellites of the Outer Planets

Dr David A. Rothery
The Open University

The giant planets have considerable families of satellites, all icy except Io. Counting Pluto and Charon, there are 18 icy bodies large enough to have assumed spherical shapes (>200 km radius). Although their outer regions are icy, the processes that occur upon and within them mimic the geological processes, such as volcanism and tectonics, with which we are familiar on terrestrial planets.

8 March 1995 7 - 8.30 pm

Missions to Mercury - Future Study Possibilities for the Innermost Planet

Prof G.H.A. Cole,
University of Hull

Preliminary Announcement - Mercury has been the target of only one space mission to date. It is now some twenty years since, over a period of ~28 months, the Mariner 10 spacecraft made a series of three fly-by encounters with the planet. Although only about one third of the surface was seen the innermost planet was found to possess a number of unique structural features. More surprising was the detection of a dipole magnetic field with a probable strength of 1% of that of the Earth's. The importance of Mercury in the study of the Solar System has now led to the possibilities of sending further missions to Mercury to come under consideration in NASA, ESA and elsewhere. In this lecture Professor Cole will review current knowledge and will be discussing the scientific aims and the options available for the study of Mercury by proposed and possible future missions to the innermost planet.

Welcome to 1995

New Year

Society Get-Together with Patrick Moore

at the

SCIENCE MUSEUM

Exhibition Road, London SW7

on 19 January 1995, 6.30 - 8.30 pm

● Refreshment Buffet

● Private Opening of Space Gallery

The Science Museum opens its doors to BIS Members offering the opportunity to meet others and view the exhibits.

For tickets, price £7.50 (incl refreshments), send to the British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ. Members may obtain a ticket for one guest subject to availability of space. Early application is advised.

Call for Papers for a Special Issue of JBIS

The pioneering role of the Society during its first 60 years of existence provided many new space concepts that significantly influenced subsequent astronomical developments.

The Society is now set to continue in this traditional pioneering role and, on the recommendation of its Advisory Committee on Science and Technology, the Council has adopted a project of wide interest and appeal. It has the theme title:

Vision 60 Plus

and its aim is to identify and review anticipated space developments over the next 60 years or more that will significantly affect the course of human progress and thought.

Preliminary guidelines have been established that offer the widest scope for contributions from the sciences, technology and sociology on a world-wide basis. Contributors can expect support from the review and presentation procedures offered by the Society's programme of publications and meetings.

To be a participant in *Vision 60 Plus* please notify the Executive Secretary of your interest and receive a copy of the Guidelines.

The first steps of *Vision 60 Plus* are already underway with the preparation of a special issue of *JBIS* for which a number of papers are in preparation and for which a Call for Papers is now being made.

Intending contributors to the *Vision 60 Plus* issue of *JBIS* should send details as soon as possible to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England.

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

5 April 1995 7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack,
Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Many potentially cheaper ways have been suggested, ranging from the plausible to the fantastic. But how to tell which is which? Can we rely on the judgement of the big space agencies? Colin Jack will be discussing the proposals, and trying to pick some winners. Suggestions from the floor will be welcome!

3 May 1995 7 - 8.30 pm

The Design, Instrumentation and Function of the Cassini Mission Titan Surface Probe (Huygens Lander)

Dr John Zamecki
University of Kent

The Cassini Huygens mission to Saturn and Titan will be one of the major missions of space exploration of the next decade. The mission will be described with emphasis on ESA's contribution, the Huygens Probe, which will land on the surface of Saturn's largest moon Titan.

JBIS



JBIS features original papers covering the full range of technical and scientific aspects of space exploration. Each issue is dedicated to a particular theme. Previous issues have featured:

Exobiology, Space Missions and Astrodynamics, History of Rocketry, Earth-Space Environment, Pioneering Rocketry and Spaceflight, Advanced Rocket Technology SOS and D2 Spacelab Operations, Nanotechnology, Soviet Astronautics, Support of the University Community for Space Science and Technology and Lunar Industrialisation and Colonization.

Readers interested in acquiring forthcoming Issues of *JBIS* might like to know that our current target plans for forthcoming issues appear as follows:

1995

January
February
March
April
May
June
July
August
September
October
November
December

Themes

Lunar Structures
Lunar-Based Astronomy
Science Systems
General Issue
New Space Concepts VI
Cray Systems (Part IV)
Pioneering Rocketry & Spaceflight (Pt V)
Mars Part I
Vega in Space or Space Communications
Terraforming or Mars Part II
SETI (Exobiology Part V)
Space Science at MSSS

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Professional Affiliation & Address (if applicable)		Job Title or Position
Signature		Application constitutes acceptance of the Society's Constitutional Rules
Date		

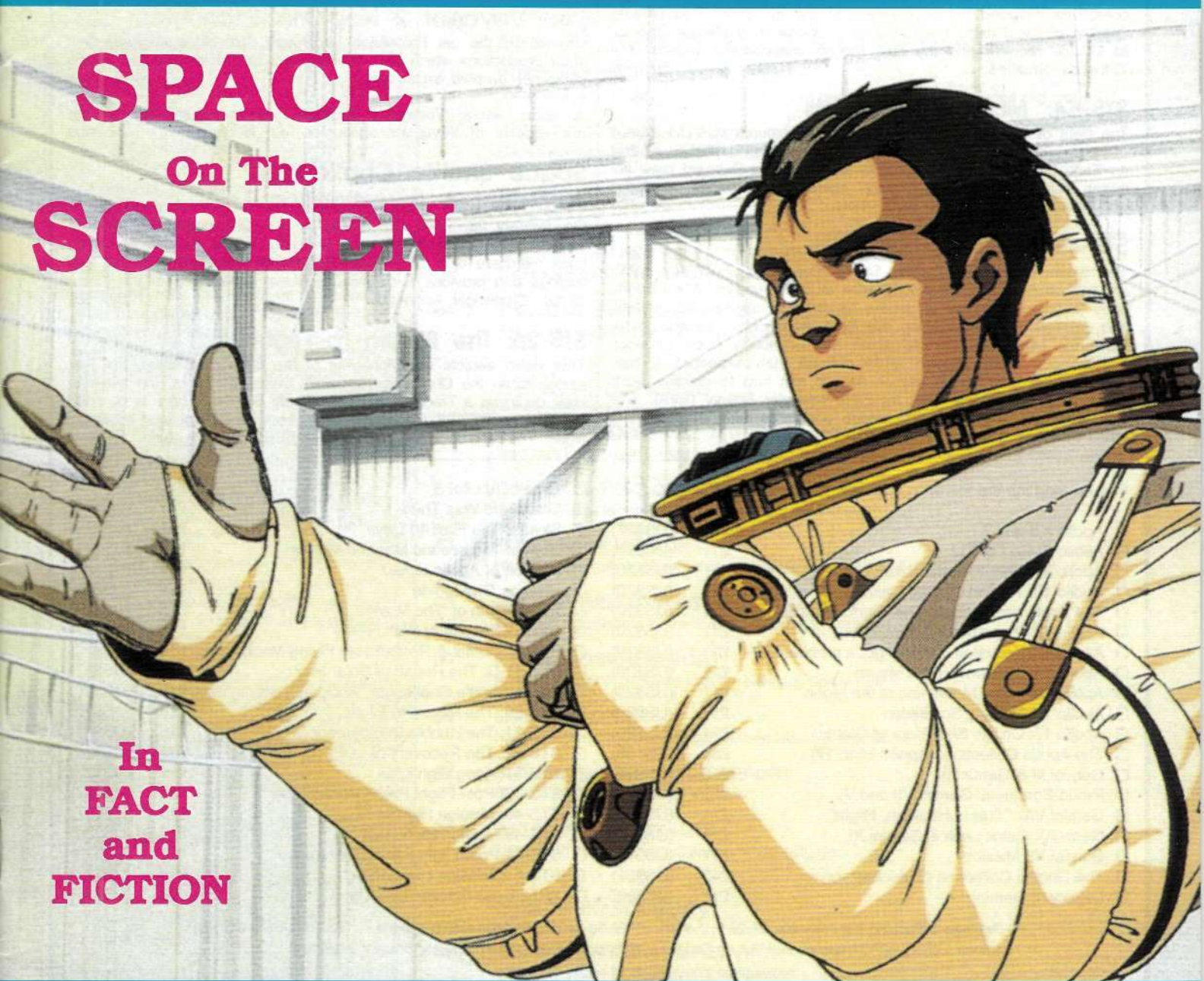
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Spaceflight

The International Magazine of Space and Astronautics

SPACE On The SCREEN

In
FACT
and
FICTION



Astronaut Shiro prepares for launch in Wings Of Honneamise

■ 'Second-Time' Space Shuttle

(RADAR'S SECOND FLIGHT AT LAUNCH ATTEMPT No. 2)

■ Problems Mar Europe's Mir Mission

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02

The BIS Video Collection

The BIS is proud to offer a stunning record of man's exploration of space brought to your home on video.
All videos are extracted from original footage.

SPACE '93 Satellite Link-Up

A fascinating, informative chat by Arthur C. Clarke, describing his work - past, present and future, as he responds to questions put by BIS members at the Society's 60th Anniversary Meeting on 17 October 1993.

The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin. A lasting and entertaining record of a unique occasion.

The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants. 50 mins

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. 50 mins

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of the Tracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. 50 mins

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbit, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). This was also very successful. The video concludes with an interesting press interview with the crew. 1hr 50 mins

Giotto - Encounter With Halley

This ESA video covers the history of the famous comet from its earliest sightings to ESA's Giotto mission that flew within 600 km of the icy body in 1986. 56 mins

Ulysses, The Movie

In this ESA video, superb computer graphics describe the mission of the ESA/NASA solar polar probe launched by the Space Shuttle in October 1990. 26 mins

A Collection of "The Movies":

LA, Earth, Mars & Miranda

plus Voyager 2 Neptune Encounter

Created by the Jet Propulsion Laboratory, this video, features four short productions which use satellite/space probe images and super-computer graphic animation. 17.5 mins

An extra feature, 'Voyager 2 Neptune Encounter', illustrates the various aspects of Voyager's encounter with Neptune. 29 mins

Space Shuttle Challenger:

Accident & Investigation

On January 28, 1986, the Space Shuttle Challenger exploded 73 seconds after blast-off from the Kennedy Space Center. All seven crew members died. This video documents task force activities and findings and provides a concise, technical explanation of the cause of the Challenger accident. 29 mins

STS-26: The Return to Flight

This video depicts the highlights of the STS-26 mission, the first launch since the Challenger accident. During the flight, the five-man crew deployed a Tracking and Data Relay Satellite. There is no commentary on STS-26 Highlights, apart from the astronauts' transmissions. The tape is accompanied by a FREE mission guide. 57 mins

Please send me the following cassette(s): Please Tick

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Spaceflight

The International Magazine of Space and Astronautics



Published By The British Interplanetary Society

Vol. 37 No. 2 February 1995

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Front Cover: *Shirotsugh* (or *Shiro* for short) dons his spacesuit in readiness for his historic mission into space, in the animated motion picture *Wings Of Honneamise*. **MANGA ENTERTAINMENT**



DESTINY IN SPACE

Filmed in IMAX

An interior view of an IMAX theatre where audiences are provided with a rare view of the entire space shuttle in its orbit around the Earth as filmed from a remote IMAX camera.

© MCMXCIV SMITHSONIAN INSTITUTION/LOCKHEED CORPORATION

Experiencing the Interplanetary Dimension

Our curiosity leads us to explore our own planet and dream of exploring others. Are we alone in the universe? Might we someday receive a signal from a distant civilisation? Could we leave Earth and travel to explore new worlds ourselves?

Sparks shoot out from the igniter as the space shuttle prepares to lit off. The giant screen fills with fire and smoke, and the shuttle hurtles into space. The journey has begun.

A shadow moves across the orbiter, cast by its robotic arm. Slowly the German observation satellite ORFEUS-SPAS with the remote IMAX camera attached to it is lifted out of the cargo bay and into a parallel orbit with the shuttle. Then suddenly, we are floating free in space. In sequences never before possible, we are outside Discovery, watching it at work.

Are we ready to cross the great black void to another planet? A journey to Mars, would be hundreds of times farther than we have ever journeyed into space. Before the dream of interplanetary travel can be realised, astronauts must learn to live and work on space stations - recycling oxygen and water, growing their own food, maintaining whole life-support systems for months or even years at a time. Keeping fit in zero gravity poses a serious challenge.

With no body weight to support, muscles weaken and bones deteriorate. During short space flights, astronauts can work out on a rowing machine, but the problem is still unsolved for longer journeys. Russian astronauts exercise up to six hours each day, yet after almost a year aboard the space station Mir they are carried from their spacecraft, temporarily unable to walk. Imagine landing on an alien planet in such a condition.

Electronic eyes and sensors of robots can explore, in extraordinary detail, the alien landscapes of planets where humans cannot safely go. The Galileo probe floats up from the cargo bay to begin its five-year journey to Jupiter, continuing the work begun over a decade ago by the Voyager probes.

In a breathtaking sequence created by computers from data transmitted by Magellan, we soar above the pancake domes and vast craters of the sweltering surface of Venus.

One day astronauts will land on Mars. At present, however, through

the eyes of robots, we can see into Mars' giant Candor Chasma, five times deeper than the Grand Canyon. Running water may have flowed there long ago. Did it nourish life? Could we transform Mars to make life possible? An imaginary "terraforming" of the surface of Mars (something that, even if possible, would take thousands of years), takes place before our eyes. As the atmosphere is somehow warmed, ice caps melt to form lakes and rivers, and clouds appear. The introduction of plants creates oxygen, making human and animal life possible. Would we then create farms and cities? Or will we leave Mars as we find it? This is a decision our descendants will have to make.

Circling other stars in our galaxy, there may be millions of planets that are already more Earth-like than Mars. Many of these could harbour life. But even our fastest rockets would take about 100,000 years to reach the nearest stars. For the present we must use telescopes to explore them.

We are entering a new age of discovery. The planets, our Milky Way, the universe beyond, all beckon. We know that the distances are vast, the voyage hazardous and the destination daunting. Still, we choose to explore. What we discover will shape our 'destiny in space'.

Breathtaking. Again

"This is the only description I can give for the new IMAX space film *'Destiny in Space'* which opened at Britain's only IMAX cinema at the National Museum of Photography, Film and Television, in Bradford, West Yorkshire on 21 November 1994."

So writes Neville Kidger, who was privileged to be one of the guests at the British premiere of the new IMAX film and has prepared this report. Following the stunning success of *The Dream is Alive* and *Blue Planet*, the new film also features extensive sequences filmed in space by shuttle astronauts.

Destiny in Space fulfils a dream of the IMAX producer Graeme Ferguson who revealed to me back in 1985 that he wanted to obtain shots of the shuttle orbiter in space with the giant camera, although he thought they might be obtained by an astronaut flying an MMU.

The shots of the orbiter Discovery against a backdrop of the Earth contained in *Destiny in Space* were taken by an IMAX camera mounted on the German ASTRO-SPAS satellite which was deployed and retrieved by the astronauts of the STS-51 mission in September 1993.

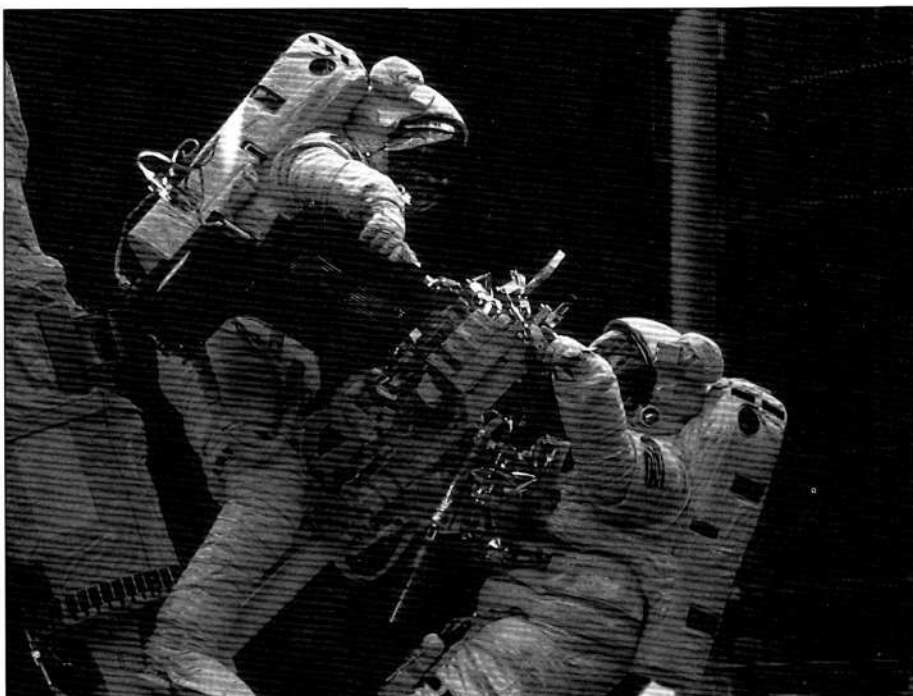
The film also contains spectacular footage of the repair of the Hubble Space Telescope by the STS-61 astronauts in December 1993.

Another innovation is the use of computer-generated scenes using radar data and images returned from the Magellan probe of Venus and Viking pictures of Mars. These sequences are as close to a virtual reality fly-over of the surfaces of those worlds as would appear to be possible.

Present at the premiere of *Destiny in Space* was NASA astronaut Captain Michael J. McCulley who was the pilot of the STS-34 mission in October 1989 which deployed the Galileo Jupiter Orbiter Probe, which features in a sequence in the film. Much of the film taken by Captain McCulley was also incorporated into *Blue Planet*.

Destiny in Space opened to the public on 22 November 1994 at the NMPFT with three showings per day Tuesday to Sunday with an extra showing on Friday evening. I strongly urge readers not to miss this super film shown on the UK's largest screen, a giant 64' x 52', with brilliantly clear image definition and a six-track surround sound. The box office number is 01274 732277.

NEVILLE KIDGER, FBIS



STS-61 (Endeavour): HST/Tools, December 1993. A scene from the IMAX film *Destiny in Space*. On the fourth of five space walks to service the Hubble Space Telescope (HST), astronauts Thomas D. Akers (left) and Kathryn C. Thornton prepare for work on the HST co-processor. Anchored between them on Endeavour's Remote Manipulator System is a mobile work station which carries an array of tools specially designed for their complex tasks.

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Production Feat of *'Destiny in Space'*

Hundreds of people were involved in getting this spectacular film footage. It required coordination between two NASA centres, the orbiter, the flight crew, and at least two data-relay satellites, to say nothing of the satellite to which the remote camera was attached. It involved the two spacecraft - one of them unmanned - flying in formation 160 nautical miles above the Earth at 17,500 mph.

Once ORFEUS-SPAS was released, the manoeuvres involved in flying away from the satellite had to occur exactly on time and with absolute precision. The pilot had to ensure that Discovery was in the field of view of the satellite, and that the satellite itself was pointing in the proper direction, so that the Remote IMAX Camera would "see" the orbiter. All this needed to happen during a daylight pass, while the shuttle was in sunlight, which only lasts for about 45 minutes per orbit. Needless to say, there were a few tense moments in the control centre.

The fact that the filming was an unqualified success was no fluke. Months of planning and preparation went into this and every other aspect of the space flight. For their role as "cinematographers in space", astronauts on each of the missions had to learn a whole new set of skills - quickly! Although all the astronauts are briefed on the use of the camera, the Commander of the space mission determines which of the crew members will receive the full 25 hours of intense training given primarily by James Neihouse (IMAX astronaut training manager) and producer

Graeme Ferguson.

In the weeks leading up to the launch, each day of the flight is "simulated". As one of the payload support teams, the film crew sits at a console with a flight data file. The astronauts are in another building, inside a shuttle mock-up. Every possible contingency is thoroughly rehearsed. "Problems" are presented for both the astronauts and the payload teams to deal with. In flight, if a malfunction occurs, the space and ground crews will have already thought of a possible solution.

Prior to every launch, IMAX technicians examine the flight cameras carefully. They spend many days checking hundreds of components to avoid any problems during the flight. This attention to detail has paid off: there have been no significant hardware failures on an IMAX camera in space. Credit goes to the IMAX technicians and to the Lockheed support team at the Johnson Space Center, who are responsible for ensuring that the IMAX hardware and that of the Space Shuttle are compatible.

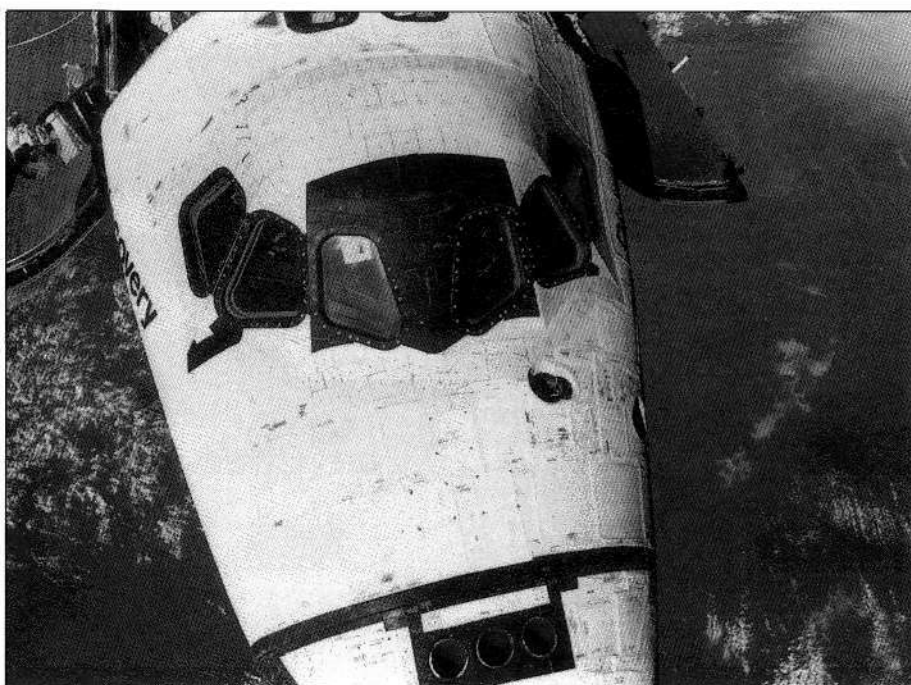
During the flight, Imax Space Team members (Graeme Ferguson, James

Neihouse, Toni Myers and Phyllis Ferguson, with two or more engineering support people) work around-the-clock shifts to support the flight crew. They constantly watch the monitors that show the orbiter's path. The "shot list" for each flight is determined months before by Toni Myers - dictated by the flight's mission and the story the film will tell. As writer/editor of the film, Myers works under the guidance of astrophysicist and Director of the Smithsonian's National Air and Space Museum, Dr Martin Harwit, and a team of scientific experts selected by the Museum. It is they who are responsible for the scientific accuracy of the film.

Myers' task is to take the disparate parts, find the "bridges" that connect them, and weave them into a story. It is a dynamic, living process, reflecting the realities that are being chronicled. When work on the film began, for instance, there was no thought that the Hubble Space Telescope would need to be repaired so soon. Yet that fact, as well as the astonishing discoveries made possible by the fully functioning HST, provide some of the most spectacular footage in the film.

A number of IMAX cameras, both on Earth and in space, were involved in the filming. "During lift off", says Ferguson, "IMAX cameras are as close as you can get to seeing a shuttle launch, in a way that no person ever can, because they're placed as close as 30 metres from the orbiter. The closest location where people can watch the launch is the press site, five kilometres away!" The camera is encased in a fire-proof box designed by NASA and IMAX engineers, its lens protected by a thick piece of quartz.

The launch-site cameras are set to start at a pre-determined time, roughly 30 seconds before lift-off. Sparks from the igniters shoot across the screen. It is a spectacular "first-time-ever"



STS-51 (Discovery): Close-up, September 1993. A scene from the IMAX film *Destiny in Space*. This close-up of the Space Shuttle Discovery was taken as the shuttle orbits the Earth by an IMAX camera mounted on the shuttle's arm.

© MCMXCIV SMITHSONIAN INSTITUTION/LOCKHEED CORPORATION

shot in IMAX, but it is very short because the camera is stationary and the shuttle is moving away at breathtaking speed.

This shuttle carries two cameras into space. There is the In-Cabin Camera which can be moved from place to place by the astronauts and re-loaded. On average there are eight rolls of film, or 24 minutes in all. Then there is the IMAX Cargo Bay Camera which is mounted in a position pre-selected by Graeme Ferguson and protected by a housing designed by NASA engineers to safeguard it and keep it at a steady temperature. It has a fixed ten minutes of film and cannot be re-loaded in flight. On the flight involving the ORFEUS SPAS satellite, the Cargo Bay Camera was mounted

on the satellite and launched with it into space. When the experiment was complete, the whole satellite was picked up by the robot arm and stowed safely back in the shuttle cargo bay, camera and all.

Two sequences in *Destiny In Space* are accurate simulations of the surfaces of Venus and Mars. They are spellbinding examples of how computers can be used to translate data collected on planetary exploration missions. Never before have images of such quality and resolution been available. Far from being fanciful "artist's conceptions", these scenes are of actual data from space probes, collected and analysed by scientists at the Jet Propulsion Laboratory (JPL), where the Digital Image Animation Laboratory has been involved in the development of scientific visualisation techniques since the early 1980s.

The soundtrack is a rich and complex weaving together of music, narration and sounds from many sources both on Earth and in space. Sounds of the astronauts at work come from three sources: on-the-spot recordings from IMAX equipment on the shuttle, air/ground exchanges during the mission, and comments from the astronauts as they viewed their work after their flight. The sound designer is Peter Thillayer.

Maribeth Solomon and Micky Erbe composed the score for a 65-piece orchestra and 35-voice choir.

The narrator is Leonard Nimoy who is best known to audiences world-wide as Mr Spock, the wonderful Vulcan character in the successful science fiction television series, *Star Trek*. ■

Quick Facts About 'Destiny In Space'

Length: 40 minutes

Sponsors: The Smithsonian Institution's National Air and Space Museum and Lockheed Corporation

Producer: Graeme Ferguson

Writer/Editor: Toni Myers

Narrator: Leonard Nimoy

Composers: Maribeth Solomon and Micky Erbe

Production Company: IMAX Space Technology Inc.

Distributor: Imax Corporation

Production period: Five years (Spring 1989 - Spring 1994)

Cost: US\$10 million

Number of:

Astronauts involved in filming = 43

Rolls of film shot during the shuttle missions = 44

Hours of IMAX camera training per astronaut = 25

Space footage was filmed by astronauts aboard:

STS-34: Galileo Deploy, October 1989

STS-31: HST Deploy, April 1990

STS-42: IML, January 1992

STS-46: Tethered Satellite, July 1992

STS-51: ORFEUS-SPAS Satellite, July 1993

STS-61: HST First Servicing Mission, December 1993

Additional scenes are from:

STS-41-C (LDEF Deploy), STS-61-B (Ease-Access) and STS-32 (LDEF Retrieval).

Computer Graphics:

Visualisations of Venus, Mars and Jupiter produced from space probe data analysed at the Jet Propulsion Laboratory.

*Japanese Animation***Putting
Science
into
Fiction**

The term science fiction is a much maligned one, especially when applied to television and cinema productions, which are often judged to contain little in the way of science, and a disproportionate amount of fiction. Sadly there is an element of truth to this charge, but if the west falls short of the ideal, then there is at least one nation in the east, where the proportions, if not quite equal, are at least considerably better balanced.

That place is Japan, a nation synonymous as no other with the development and application of high technology concepts in the home, office and factory, and if Japan has yet to come fully of age as a space faring nation, then the hearts and minds of the Japanese people are at least well prepared for the inevitable day it does. Nothing has done more to ennoble this idea with the public than the massive output of the Japanese animation studios, who for decades have been inspired by the march of technology and doubtless in turn have inspired the next generation to make real that which was once fiction.

Wings Of Honneamise

Japanese animation, or anime as it is called, has in recent years found new converts in the west, and here in Britain has proven especially popular. November 1994 saw a limited cinema release for a movie which could justifiably be called the Japanese equivalent of 'The Right Stuff', telling as it does of the courage of a young man, determined to be the first of his people to venture into space. That movie is *Wings Of Honneamise*, or as it is otherwise known, The Royal Imperial Space Force.

When first we meet him however, the hero of the film seems to have little of the right stuff in him. Shirozugh Lhadatto has lost all drive and ambition since failing to make the grade as a navy pilot, a dream he had nurtured since childhood. Full of self pity, he has instead joined The Space Force of The Kingdom Of Honneamise, a project fast running out of funding as frequent launch failures erode vital prestige and morale.

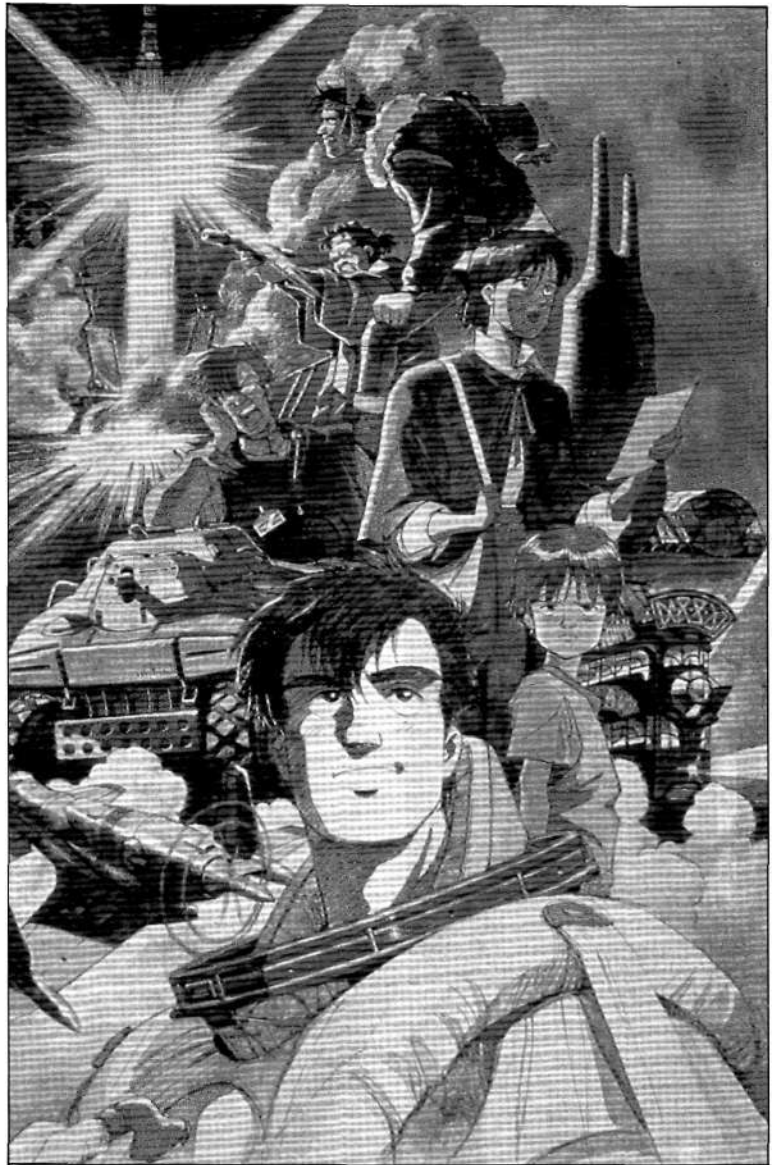
Shirozugh (or Shiro for short) is at an even lower ebb than usual after attending the funeral of a colleague killed in an accident with a faulty spacesuit, (his urine sack burst and he

was electrocuted) and after a night out drinking with the other space force incorrigibles, he finds himself alone with his thoughts in a seedy part of town. It is here that a chance encounter with a young girl, preaching the virtues of a religion all but swept aside by progress, is to have a dramatic influence on his life.

Shirozugh visits the girl at her countryside home the next day, and is deeply moved, when contrary to the reaction of most people upon learning of his job, she actually professes admiration for his work, and a hope that it will inspire people to live together in peace, for war clouds are gathering over Honneamise. The following day, the beleaguered General in charge of The Space Force has a shocking announcement. It has been decided to attempt a manned launch to restore the honour of the force, and will a volunteer step forward? To the amazement of his colleagues, Shi-

rotzugh volunteers, and thus begins an intensive training course, which as the weeks go by, begins to lift the spirits of all involved.

The substance of that training programme is chronicled in superb detail, from the contents of the astronaut's breakfast, to the construction of the rocket and testing of the engines. Meanwhile the pressure of becoming a public hero mounts for Shirozugh, while tensions with a rival nation also escalate, and the rocket risks becoming a pawn in a potentially catastrophic struggle. As you may have guessed then, the nation of Honneamise has many parallels with Earth, politically, socially and technologically. The latter is not so surprising, since the primary production staff not only travelled to the American Smithsonian Air And Space Museum to research rocket and aircraft designs, but also took the opportunity to view a launch of the Space Shuttle Discovery. From this extensive groundwork there was developed a detailed technological style and ambience for the movie, part real, part imagined, that in contrasting



A dramatic montage of key images and characters from *Wings Of Honneamise*.

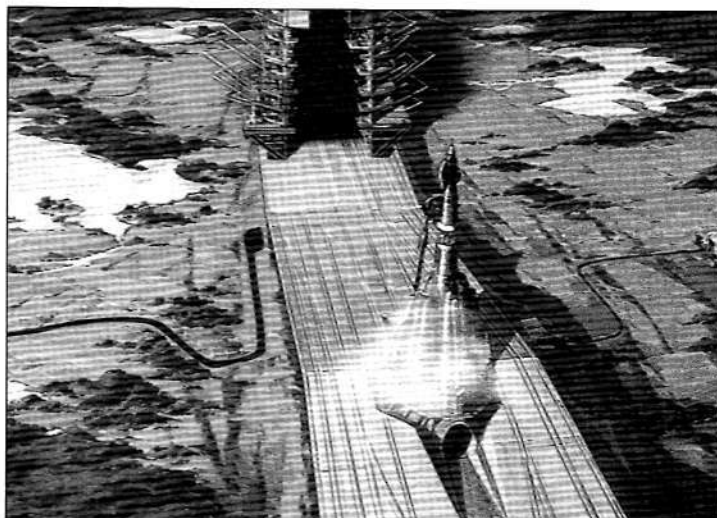
BY JOHN GOSLING

Milton Keynes, UK

the retrograde aspects of Honneamise society, (gas street lamps and monochrome television) creates a world that is at once both alien and hauntingly familiar.

For instance, when first we see the rocket which is to carry Shirotzugh into space, the similarities with Soviet rocket designs are strikingly apparent, and when the engines ignite, the viewer cannot help but be reminded of the classic film of the mighty Saturn 5, cascades of dislodged ice falling from it as it thunders from the pad. Once in space, the final stage of the rocket is seen to echo the design of the Vostok capsule. As it orbits the world, Shirotzugh becomes the first of his race to witness the brilliant dawn of a new day from space.

When released in Japan in 1987, *Wings Of Honneamise* was not the



The launch tower is retracted in readiness for liftoff (*Wings Of Honneamise*).



Shiro in his ceremonial Space Force uniform at the moment when he steps forward and volunteers for the mission (*Wings Of Honneamise*).

great commercial success it was hoped for, this despite a very visible budget on the screen of 8 billion yen, and the efforts over several years of some 3000 staff. The problem was that the comparatively slow pace of the film was not in keeping with the vogue at the time for epic space war stories, however, it did win widespread critical acclaim, and has remained a firm favourite with animation fans the world over.

Do not make the mistake of dismissing this film as something comparable

to a Disney film. At almost two hours long, it is a complex and moving portrait of a great endeavour, and the lives touched by it. The animation too is of a calibre not to be dismissed lightly, achieving a degree of realism that is at times awe inspiring in scale and grandeur, but also providing much to delight and amuse the viewer in its painstaking portrayal of everyday life in the Kingdom Of Honneamise. Couple this with a rousing musical score from Oscar Winner (for *The Last Emperor*) Ryuichi Sakamoto, and you have all the makings of a truly extraordinary movie experience.

Now dubbed into English, *Wings Of Honneamise* will soon reach a wider audience still, with a video release scheduled in February 1995. This is definitely a film no one with an interest in space flight should miss, but, believe it or not, it is just the tip of the iceberg.

Space Habitats

If their frequent appearance in anime productions is in any way indicative of public opinion, then the concept of the space habitat has clearly struck

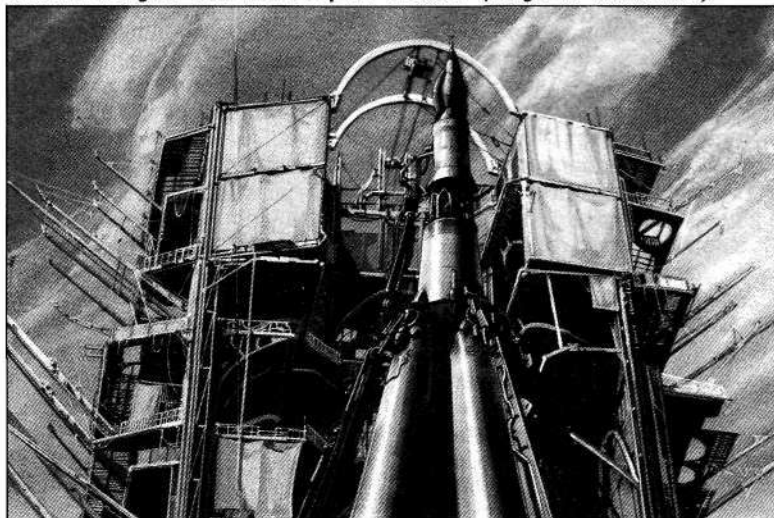
a responsive chord with the Japanese. It is not unreasonable to theorise that their historically rooted desire for seclusion will make the Japanese good space colonists, and as signified by such mammoth projects as the recently completed Kansai International Airport, which required the building of a huge artificial island, they are prepared to expend large sums of money and effort on projects deemed to be of national importance, with scant regard for the enormity of the problems to be faced.

The idea of going on to build islands in space may seem a flight of fancy, but for the Tokyo based Obayashi Corporation, the prospect is not so farfetched. They have developed detailed plans for a Mars Colony, a remarkable feat for a company better known for their Earthbound commercial construction projects. Projects such as the Mars Colony arose initially from the realisation that the Japanese construction industry was seen by the public as Kiken, Kitani and Kitsui, dangerous, dirty and hard, or what became known as the Three K Problem. To counter this, any number of high profile, high tech projects were instigated to improve public opinion, though to their credit, Obayashi anticipate that space colonisation will become a major business opportunity in the future. However, space habitats had already captured the public imagination in another way, when in 1979 the animated series *Mobile Suit Gundam* premiered on Japanese television.

Robotic Reverence

Gundam boasts one of the most detailed backgrounds ever created for a fictional world. Even the basic story is too complex to summarise here except in the most simplistic terms. Suffice to say that in the near future, an environmental catastrophe on Earth has forced the relocation of several billion humans to space habi-

The rocket that is to carry Shirotzugh into space is clearly inspired by Russian designs. Note the strap-on boosters (*Wings Of Honneamise*).

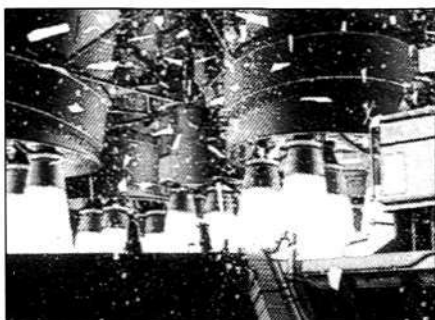


tats, which in time, assume the same nationalist postures so ruinous to Earth. The title refers to the giant piloted robots deployed in the ensuing wars. Such Mecha, as all robots are generically called in anime, are themselves worthy of note in this essay, since the construction of space habitats on an immense scale will surely require some sort of assistance from robotic labour.

Considering that the west has invested heavily in a man intensive space programme, such a departure from present thinking would require a radical change in our attitude to robots, but the Japanese have already developed a special relationship with robots in the workplace, to the extent that industrial robots of the kind to be found in car plants are often given individual names by their human co-workers, and sometimes even blessed on installation by Shinto priests. This is not surprising, given that a major tenet of the Japanese Shinto religion is that everything from trees and rivers, to ploughshares and swords, is thought to have something akin to a soul called a Kami. Given this fact then, it is clear that the Japanese have us at an advantage, not having developed the innate fear and distrust of robots reflected in our films and literature. That in such stories we often turn our soulless machine creations upon us to destructive ends is what might be termed a Frankenstein phobia, born of a Christian society that teaches us that God alone has the authority to create life.

Japan is the only nation in the world with any serious programme of research underway into bipedal robots, something considered to be an academic dead end by western scientists, but from the earliest days of the genre in the 1950's, anime has portrayed robots as humanoid. Today, mecha have been anthropomorphized to such a degree that they have become equal partners with humanity in the exploration of space. However, it is the colonies which are of special interest in Gundam, as they are modelled on the designs of Princeton professor Gerard K O'Neill. Modelled so closely in fact that they have been placed in the story at the five Lagrange

Cascades of ice fall from the rocket as the engines ignite reminiscent of Saturn 5 liftoffs (*Wings Of Honneamise*).



The design of the manned capsule in *Wings Of Honneamise* (here seen flying into the dawn) appears to be closely modelled on the Russian Vos-tok capsule.

Points, locations ideal for large colonies, since positioning them thus almost negates the need for frequent and fuel intensive orbital corrections. The Moon also features prominently in Gundam, most notably in the shape of Von Braun City, which has been touchingly located in Cayley Crater, not too far from the landing site of Apollo 11.

Gundam has not yet found a western distributor, but there are other examples of scientifically realistic anime that have. Almost fifteen years after it was first broadcast, new Gundam stories continue to be made and, indeed, each episode of the latest series opens with a lingering shot of a classical O'Neill Colony.

Scientific Realism

Samurai Gold, (Western Connection) is a fast paced action comedy set for much of the time in an O'Neill colony. A murder attempt on his father sets the hero, a character based on a folk hero of old Japan, on a journey into space aboard a commercial passenger Space Shuttle, destination a space habitat. Just as in Gundam, we see the interior of a cylindrical space colony with rivers, roads and fields appearing to curve up the walls in spectacular defiance of gravity. It must be admitted that the colony in Samurai Gold is little more than a decorative backdrop and plays no active role in the story, but I ask you, can you name a single western science fiction film that has so utilized the concept?

Another example of scientific excellence in anime is Gunbuster (Kiseki Films) a three part epic spanning tens of centuries of future human history. It should be explained that Gunbuster liberally mixes accepted theories and principles with a fictional science all of its own, but it still comes far closer to the ideal of science fiction than any-

thing Hollywood has yet produced. In the near future, a war is underway between humans and aliens, a war fought at near light speed velocities, with all the incumbent dangers for the combatants of returning to find their loved ones aged or dead, while they themselves have retained their youth, just as postulated in Einstein's theories of time and space. This idea is used to powerful emotional effect throughout the story. Also featured in the three volume Gunbuster saga (the name of the giant robot built to counter the alien threat) are two-stage spaceplanes and a wonderfully eccentric vision of a space elevator; the concept of tethering a cable from a fixed point on the Earth's surface to a low orbital station of sufficient mass, probably a captured asteroid.

Conclusion

At its best, anime is a unique blending of science, fiction and an unbounded optimism for the future, though modern productions do boast their share of dystopian futures. The appeal of anime is by no means limited to children, though if popular press stories concerning the level of violence have come to your attention, then you should understand that though this can be the case, the examples cited in this article are suitable, with the proviso that they contain scenes of brief nudity and mature themes, for older children.

Of course while much of the anime released in the UK has been science fiction (as is a high percentage in Japan), not all are as scientifically inclined as I have described above but if you have ever wished to see science fiction brought to life on the small screen in the spirit of such masters of the written word as Arthur C Clarke, Robert Heinlein and Isaac Asimov, look no further.

Illustrations: MANGA ENTERTAINMENT

Have Rocket Will Travel

Cinematic Visions of the Dawn of the Space Age

This summer should see the release by Universal Pictures of *Apollo 13*, the filmed account of the failed moon flight which is based on Jim Lovell's book, *Lost Moon*. The film is directed by Ron Howard and features recent Oscar winner Tom Hanks in the role of Lovell.

How *Apollo 13* fares in the traditional summer box-office bloodbath against the likes of such potential heavyweight contenders as *Batman Forever* and the new Bond movie *Goldeneye* remains to be seen, but history shows that films predominantly based on past or recent developments in astronautics have had little widespread appeal. When one looks back at the antecedent portrayals of space technology on the big screen it is not hard to see why this should be so.

Paths of Glory

Hollywood is known throughout the world as the dream factory, but it would seem that it has done very little to keep "the" dream alive. Ask most cinemagoers for their impressions of space and they might well recall the pyrotechnics of George Lucas' *Star Wars* trilogy, the mawkish sentimentality of Steven Spielberg's *ET*, or the schlock-horror of Ridley Scott's *Alien*. Many doubtless even hanker for the buccaneering adventurism of the *Star Trek* series.

Only one film, it seems, has come anywhere close to providing a realistic appraisal of the intricacies of space travel, that being Stanley Kubrick's *2001: A Space Odyssey*. In a sense it is the mother of all sf movies and remains one of the most breathtaking films created in the history of the cinema. Yet while the dawn of the new millennium immortalised in the film's title draws inexorably nearer, the drama of *2001* is played out on what seems to be an increasingly distant future.

So what of the here and now, or indeed the recent past?

As anyone with an interest in the subject knows, Man's pioneering exploits in space should offer plenty of scope for good drama, but there is not much evidence to support this case. There has been the odd "factionalised" drama having some basis in real events, and an even greater number of "spaceploitation" films in which real space technology has appeared as a decorative accessory. But not only have such films been lack-lustre, in many cases they have been downright defamatory.

Modern Times

Louis Lumière, a key figure in the development of the moving image, famously remarked that "The Cinema is an invention without a future". He was wrong on two counts. Wrong because the cinema became the first of the recorded arts to gain a foothold in the everyday lives of the general public, and wrong because throughout its history the cinema has been more than willing to

BY DARREN L. BURNHAM

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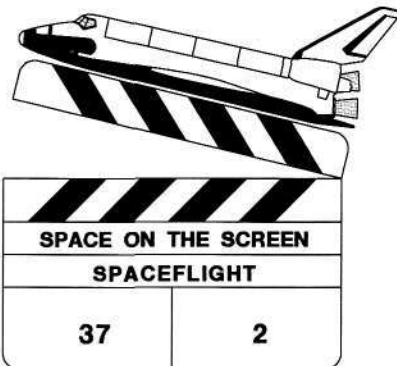
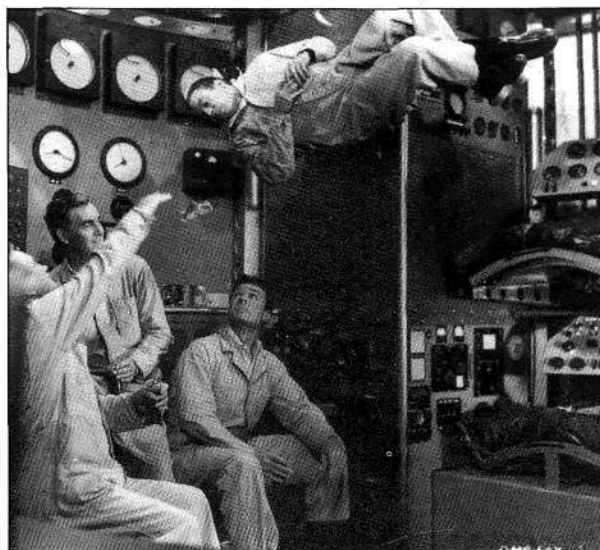
explore the potential of futuristic science fiction.

Doubtless the appeal of science fiction lies in the fact that it was the one genre which allowed the fledgling cinéastes to evince the full range of camera and processing tricks at their disposal. For an example one need look no further than *Le Voyage dans la Lune* (A Trip to the Moon) [Star, France, 1902], Georges Méliès' seminal masterpiece which borrowed heavily from both Jules Verne's 1865 novel *From the Earth to the Moon* and H.G. Wells' *The First Men in the Moon*. Other highly regarded landmarks between this and *2001* [MGM, GB, 1968] included *Things to Come* [London Films, GB, 1936], *Destination Moon* [Universal, US, 1950], and *Forbidden Planet* [MGM, US, 1956].

Yet while film makers have zealously embraced the advances of science and technology, they have so often ended up selling the real rocket scientists short. An early sign of the problems which lay ahead came when Hermann Oberth, the father of German rocketry, assisted Fritz Lang in the production of *Die Frau im Mond*

A scene from *Destination Moon*: the occupants of the control cabin enjoy some light relief in testing zero-gravity conditions.

© 1950, AN EAGLE LION FILM



(The Woman in the Moon) [UFA, Germany, 1929]. The experience was not a happy one for Oberth, who's role soon expanded to the point where he was supposed to launch a real rocket as a publicity stunt in order to help promote the film. Before long he returned home to Rumania, disillusioned by the damage the whole sorry affair had done to his reputation [1].

The problem was that the film-makers were far ahead of the game and in many ways were waiting for the real hardware to catch up with their own imaginations. Not even the arrival of the space age with the launch of Sputnik in October 1957 made much of an impression in the face of a continuous onslaught of alien invaders in full Technicolor glory!

Marathon Man

It was not until 1968 that the first semi-factual drama centred around the activities of NASA hit the theatres. The film in question was *Countdown* [Warner, US, 1967], though it is better remembered in the film world for marking director Robert Altman's Hollywood debut. Based on the 1964 novel *The Pilgrim Project* by Hank Searls, *Countdown* tells the story of a last ditch attempt by NASA to steal a march on the Soviets by launching a single astronaut on a one-way trip to the Moon.

As Apollo supposedly is not ready yet, the hardware for this unlikely plan is a Gemini capsule mounted atop an Apollo LM descent stage - which is rather odd since the LM was the last piece in the Apollo jigsaw to fall into place. Not that *Pilgrim* is meant to be a suicide mission, for upon arrival on the Moon the brave astronaut will transfer over to a shelter module to await recovery by an Apollo mission some 9-12 months later.

Being a quickie B-movie filmed on a budget of \$1-million there are no cataleptic voyages through space here. The main focus of the picture is the ribaldry between the military astronaut originally assigned to the mission [Robert Duvall] and the civilian pilot

[James Caan] who takes his place at the behest of the State Department. Further complications come in the form of the Chief Flight Surgeon who believes that the plan is harebrained and does everything within his power to stop the flight going ahead.

The rivalry on-screen was matched by an equal measure of controversy off screen. To this day Altman claims that he was sacked by Warner Brothers before the completion of filming and that veteran studio boss Jack Warner decided to edit the film himself. Much to Altman's chagrin, out went his low-key, open ended climax in favour of Warner's more predictable ending, sonorous with Stars and Stripes and mom's apple pie symbolism [2].

The Great Escape

Marginally more satisfying, though barely any more successful, was *Marooned*, released by Columbia in 1969. It took almost as long to put a man on the Moon as it did to transfer Martin Caidin's 1964 book to the screen. The original novel was a felicitous little melodrama about a Mercury astronaut left stranded in space when his retro-rockets fail at the end of the three-day MA-10 mission. Soon after the book was published in 1964 the film rights were purchased by Columbia Pictures who planned to release the film in 1965.

For various reasons the project did not go ahead as planned and it was not until the late 60s that the cameras finally started rolling. By this time the march of progress had rendered the

Critic Quotes

I Aim At The Stars

"Von Braun possibly has grounds for a libel suit, but then he might do better to ignore the picture. So might everybody else." - *Time*.

Countdown

"Makes the moon seem just as dull as Mother Earth" - *New York Times*.

Marooned

"Marooned" rates about one-half out of a possible 2001" - *Time*.

Diamonds Are Forever

"It has been claimed that the plot is impossible to describe, but I think I could if I wanted to. I can't think why anyone would want to, though" - *Roger Ebert*.

Capricorn One

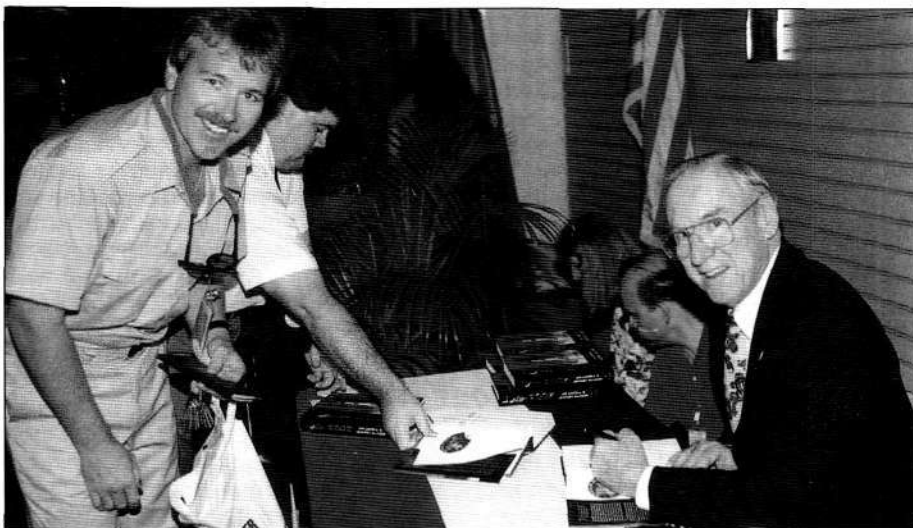
"After weighing in with some Watergate/Bernstein pretensions, the makers then opt for boring, Bondish derring do" - *Sight and Sound*.

Moonraker

"Conspicuously expensive production values but an unmistakably cut price plot" - *Sight and Sound*.

SpaceCamp

"Hampered by cliché-ridden dialog, performances suffer from a weightlessness of their own" - *Variety*.



Gemini and Apollo astronaut Jim Lovell signs a copy of his book *Lost Moon* for Joseph Chapat Jr, the captain of the NASA SRB (Solid Rocket Booster) retrieval ship Liberty Star. The book, an account of Lovell's ill-fated Apollo 13 moon shot, is being made into a movie by Ron Howard and will star Tom Hanks in the role of Lovell.

PETER GUALTIERI, WEST KENTUCKY NEWS

original plot somewhat *passé*. A new scenario was therefore developed in which the condemned spacecraft became an Apollo capsule (Ironman) returning home after a stay of several months aboard a space station adapted from a Saturn booster.

In common with *Countdown*, *Marooned*'s director John Sturges chose to focus on the human angle, with top billing being given to Gregory Peck as the director of the manned space programme. The plot "kind of falls apart" [3] once the director, best known for Westerns such as *The Magnificent Seven*, calls in the calvary to rescue the stranded crew. The stultifying climax sees an unlikely orbital troika in which a Soviet spacecraft and an American X-RV lifting body cooperate to rescue what is left of the Ironman's crew (the Commander [Richard Crenna] already having done the honourable thing so that his colleagues [James Franciscus and Gene Hackman] may have a chance to live).

The film suffers most during the EVA sequences which are just not convincing, even though they walked off with that year's Oscar for the best Special Effects. This is not a problem which is confined to *Marooned* alone. Space is such an unworldly environment that its effects are difficult for mere Earth bound mortals to cogently re-create. The special effects staff can make Superman fly and make it look fairly convincing, but no amount of trickery can disguise the presence of gravity. Until an enterprising director takes the step of hiring the KC-135 "vomit comet" and building a mock spacecraft set inside the fuselage it is a problem which will continue to blight all space films.

Crimes and Misdemeanors

Probably the most infamous of all movies about the space programme -

a real cinematic Bay of Pigs if you like - was *Capricorn One*, released by Lew Grade's ITC in 1978. Basically it is a case of the space programme meeting the Watergate scandal in a head on collision. Quite an explosive combination it turns out to be too - the ensuing wreckage is strewn far and wide!

Nominally about the first manned mission to Mars, *Capricorn One* soon shoots off in a different direction when the astronauts are ushered away from the capsule moments before the launch. It transpires that NASA has reason to believe that the mission will go horribly wrong. The space agency fears that such a public failure will sound the death knell of the space programme as a whole. This cannot be allowed to happen and so NASA and its industrial benefactors conspire to mount a "successful" mission for the benefit of TV viewers from a secret facility in Nevada. Pop the astronauts back into the capsule after its splash-down and nobody will be any the wiser, or so the theory goes.

Unfortunately for NASA, the mission really does go horribly wrong when the unmanned capsule burns up while re-entering Earth's atmosphere. This leaves them with three astronauts [James Brolin, Sam Waterston & O.J. Simpson] who have suddenly become non-persons in the most literal sense imaginable. For a fleeting moment the film has the potential to become a truly great black comedy along the lines of *Dr. Strangelove*. Unfortunately director and screenwriter Peter Hyams jabs the chicken switch and opts instead to try and create what was billed as "one of the most exciting adventure sequences ever filmed". The astronauts escape from their captors and the omniscient combat troops of the military-industrial complex start dishing out some nasty unscientific assistance in retaliation.

Though *Capricorn One* is ostensibly about a hypothetical mission to Mars, the implicit sub-text is that the Apollo Moon landings were similarly faked - only the names and places have been changed to protect the innocent. All of the hardware on show is from the Apollo era, even though this would be hopelessly unsuited to the requirements of a much longer Mars mission.

Amazingly, though the film's specious arguments will have done it no favours, NASA gave full cooperation

to the *Capricorn One* team, as was in fact the case with most of the productions discussed in this article [4].

Sudden Impact

Following *Capricorn One* Apollo was retired from service and the Space Shuttle became the predominant image of the space programme in the 1980s. The first high-profile movie to feature the Space Shuttle was *Moonraker* [UA/Eon, GB], the eleventh film in the highly successful

James Bond series which was released in 1979.

One way or another the Bond films had a long record of associating themselves with the paraphernalia of the space programme [5]. The very first in the series, *Dr. No* [UA/Eon, GB, 1962], featured the eponymous "world class criminal" in an effort to disrupt the US Moon programme by using a radio jamming device to "topple" rockets launched from the Cape. Coming as it did in the thick of the Cuban missile crisis, *Dr. No's* seductive cocktail of sex, sadism, and space technology hit the target with the unerring accuracy of any of the number of bullets fired from Sean Connery's Walther PPK.

Later in the decade - with the Bond films firmly established as the biggest box-office draws going - *You Only Live Twice* [UA/Eon, GB, 1967] again featured a criminal genius meddling in space shots. This time the spacecraft were manned and the dirty deed was done while the vehicles were actually in orbit. The high ground was also captured in *Diamonds Are Forever* [UA/Eon, GB, 1971] in which a laser equipped polar orbiting satellite is used to neutralise American, Soviet and Chinese nuclear weaponry.

The Space Shuttle assumed centre stage in Roger Moore's fourth outing as 007 thanks to "Cubby" Broccoli's desire to conceive a movie which would compete with the likes of *Star Wars* and *Close Encounters of the Third Kind*.

Though claims were made to the effect that *Moonraker* was based in science fact, not in science fiction, you did not need to be a rocket scientist to realise that this statement did not stand up to close examination. The film begins with the in-flight hijacking of a *Moonraker* space shuttle from atop its 747 carrier aircraft. It ends a dozen or so reels later in a big set-piece battle (what else?) in which a platoon of laser equipped space marines disembark from the payload bay of a US Space Shuttle in order to mount an assault on the villain's space station - a 200 metre diameter structure surreptitiously placed in orbit!

To be truthful the villain is not the only thing connected with this picture which should have been pushed out of the airlock. But besides being great fun, *Moonraker* does have some pluses, particularly the Oscar nominated special effects. Given that the Shuttle was several years away from making its maiden flight, this was one occasion where the film-makers could not rely on the usual trick of cutting to some stock launch footage, and in the event the *Moonraker* launch sequences turned out to be surprisingly realistic.

The image of the Space Shuttle as the great white hope of the future was further enhanced by *Starflight One*

Filmography

I Aim At The Stars

Released by Columbia Pictures, 1960
 Producer: Charles H. Schneer
 Director: J. Lee-Thompson
 Leading Players: Curt Jurgens, Herbert Lom, James Daly and Gia Scala

Dr. No

Released by United Artists, 1962
 Producers: Harry Saltzman and Albert R. Broccoli
 Director: Terence Young
 Leading Players: Sean Connery, Ursula Andress and Joseph Wiseman

You Only Live Twice

Released by United Artists, 1967
 Producers: Albert R. Broccoli and Harry Saltzman
 Director: Lewis Gilbert
 Leading Players: Sean Connery, Donald Pleasence, Akiko Wakabayashi and Tetsuro Tamba

Countdown

Released by Warner/Seven Arts, 1968
 Producer: William Conrad
 Director: Robert Altman
 Leading Players: James Caan, Robert Duvall, Barbara Baxley, Steve Ihnat, Charles Aidman and Joanna Moore

Marooned

Released by Columbia Pictures, 1969
 Producer: Mike J. Frankovich
 Director: John Sturges
 Special Effects: Robbie Robertson
 Leading Players: Gregory Peck, Richard Crenna, David Janssen, Gene Hackman and James Franciscus
 Oscar Awards: Visual Effects
 Nominations: Cinematography and Sound

Diamonds Are Forever

Released by United Artists, 1971
 Producers: Harry Saltzman and Albert R. Broccoli
 Director: Guy Hamilton
 Leading Players: Sean Connery, Charles Gray and Jill St. John
 Oscar Nominations: Sound

Capricorn One

Released by Associated General/Lew Grade, 1978
 Producer: Paul N. Lazarus III
 Director: Peter Hyams
 Leading Players: James Brolin, Elliott Gould, Brenda Vaccaro, Hal Holbrook, Sam Waterston, O.J. Simpson and Telly Savalas

Moonraker

Released by United Artists, 1979

Producer: Albert R. Broccoli

Director: Lewis Gilbert

Special Effects: Derek Meddings

Leading Players: Roger Moore, Michael Lonsdale, Lois Chiles and Richard Kiel
 Oscar Nominations: Visual Effects

Starflight One (Aka: The Plane That Couldn't Land)

Released by Orion Pictures, 1982
 Producers: Peter Nelson and Arnold Orgolini
 Director: Jerry Jameson
 Special Effects: John Dykstra and Terry Frazee
 Leading Players: Lee Majors, Hal Linden, Lauren Hutton and Ray Milland

The Right Stuff

Released by Warner Bros., 1983
 Producers: Robert Chartoff and Irwin Winkler
 Director: Philip Kaufman
 Leading Players: Sam Shepard, Scott Glenn, Ed Harris, Dennis Quaid, Fred Ward and Barbara Hershey
 Oscar Awards: Original Score, Film Editing, Sound, and Sound Editing
 Oscar Nominations: Best Picture, Supporting Actor (Shepard)
 Cinematography and Art Direction

Terms of Endearment

Released by Paramount, 1983
 Producer and Director: James L. Brooks
 Leading Players: Shirley Maclaine, Jack Nicholson, Debra Winger and John Lithgow
 Oscar Awards: Best Picture, Actress (Maclaine) Supporting Actor (Nicholson)
 Direction and Adaptation
 Oscar Nominations: Actress (Winger) Supporting Actor (Lithgow), Film Editing, Art Direction, Sound and Original Score

SpaceCamp

Released by ABC Motion Pictures, 1986
 Producers: Patrick Bailey and Walter Coblenz
 Director: Harry Winer
 Special Effects: Barry Nolan
 Leading Players: Kate Capshaw, Lea Thompson, Kelly Preston, Larry B. Scott, Leaf Phoenix, Tate Donovan and Tom Skerritt

Superman IV: The Quest For Peace

Released by Cannon, 1987
 Producers: Menahem Golan and Yoram Globus
 Director: Sidney J. Furie
 Special Effects: Olsen, Lane and White
 Leading Players: Christopher Reeve, Gene Hackman and Mark Pillow

[Orion, US, 1982], a made-for-TV disaster movie in space which for reasons unexplained also received a limited theatrical release.

Blackboard Jungle

Of all the films discussed in this article, none has been more badly timed than *SpaceCamp* [ABC, US, 1986]. Prompted by the real US Space Camp at the Space and Rocket Center, Huntsville, Alabama, *SpaceCamp* was supposed to sing the praises of the Space Shuttle and serve as a rallying cry to the next generation of astronauts. Unfortunately, the film was released in the wake of the Challenger accident in 1986 when the reputation of the Shuttle programme was at its nadir.

The film enters a flat spin right from the point when John Glenn makes his apocryphal night-time transit across North America. As is its wont, NASA allows a crew of juvenile astronauts and their astronaut instructor [Kate Capshaw] to sit aboard the Shuttle Atlantis during a static firing of its main engines. However, thanks to the intervention of a venerable Hollywood favourite - the cute loveable robot - they are inadvertently catapulted into space to become the latest in a long line of accidental spacefarers [6].

Once in space the Shuttle and its crew lunge from disaster to disaster (in both a dramatic and cinematic sense) as they bid to return home. Like so many of the films discussed here, *SpaceCamp* chooses to take a pick 'n' mix approach to the problems of space travel. For example, there is a vague understanding that Shuttle flight operations are dictated by things called "windows", and that these constrain the times at which the Shuttle can re-enter. Playing upon this fact the film-makers are able to spin out the story so that the rookie astronauts have to rendezvous with the space station Daedalus and make a spacewalk so as to replenish their oxygen supply.

However, as the film nears the end of what Shakespeare described as "the short two hours' traffic of our stage" the curtains are adroitly brought down thanks to some bright spark suggesting the use of an alternative landing site. - Brilliant thinking! Quick, someone dig out the data on STS-3 at White Sands back in '82!

Angels With Dirty Faces

So much for the fiction, but what of the faction? Prior to *Apollo 13*, only two Hollywood big screen productions have provided dramatised accounts based on figures actually involved in the exploration of space.

The first such effort *I Aim At The Stars* [Columbia/Morningside/Fama, US, 1960] was a stodgy biopic of the pre-Apollo career of Wernher Von Braun [Curt Jurgens]. Sanitised by

Von Braun's current employers, the US Army, and embellished by the scriptwriters, the film bore little resemblance to the truth. Nevertheless, Von Braun's Nazi background proved to be a bone of contention and protests were held at screenings in both London and New York. It was even banned in Antwerp, the city which suffered the worst pummelling at the hands of the V-2 [7].

Slightly less controversial (but only just) was Philip Kaufman's *The Right Stuff* [Warner/Ladd, US, 1983]. Cinéma-vérité it is not. The film attempts to mythologize the early history of the US manned space programme. Whether the early history of the US manned space programme needed mythologizing in the first place is another question entirely.

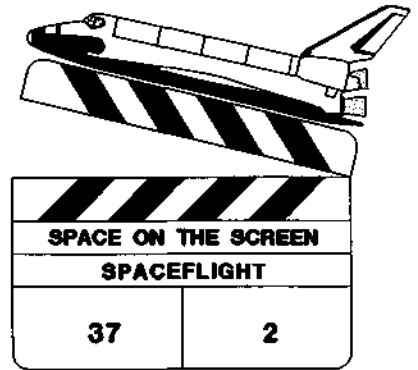
The screenplay remains reasonably faithful to Tom Wolfe's original book about the "young bucks who shoot dice with death" in a technological game of "acey-deucey, one finger-two finger" [8]. In presenting Wolfe's "artful euphemisms" on screen the *The Right Stuff* proves to be rather economical with the actualité. The main characters - Chuck Yeager [Sam Shepard] and the Mercury Seven [Scott Glenn, Ed Harris, Fred Ward and Dennis Quaid et al] - are surreal images of themselves, painted on the canvas of the screen with exceptionally broad brush strokes. The lesser figures (officialdom, engineers and scientists) are reduced to the level of a few nameless "types" whose role in events is only fleeting.

Soviet Influence

Soviet space technology makes a rare cameo appearance in *Superman IV*, Cannon's low budget addition to the big screen series of the late 70s/early 80s. The tone of the picture - in which Superman [Christopher Reeve] fights for nuclear disarmament and world peace - is set very early on when the man from Krypton grapples with what looks amazingly like an authentic scale model of the Salyut space station in order to rescue a trio of imperiled Soviet cosmonauts. Even the All-American hero, it seems, cannot resist the forces of Glasnost (not that he would have refused to help during the Cold War anyway).

Normally when Soviet cosmonauts make an appearance in a movie it is invariably to ameliorate the sense of "them" and "us", such as was the case in *Countdown*. Broadly speaking, Continental film-makers have demonstrated a far greater willingness than their American counterparts to turn the spotlight towards the Soviet space programme.

Take for example *A Pied, à Cheval et en Spoutnik* (aka *A Dog, a Mouse and a Sputnik*) [Films Around The World], a French film released not long after the launch of Sputnik 1. It is a lightweight



The cruellest characterisation is that of Vice President, Lyndon B. Johnson, and the image of the "hideous hand-wringing Texan" being turned away from Annie Glenn's front door is truly unforgettable. The only figure who seems to be above all this nonsense is President Kennedy, who briefly appears in the form of some cleverly retouched archive footage which foreshadowed the more recent *Forrest Gump*.

As one would expect of a film three years in the making, technically it is hard to fault *The Right Stuff*. Embroidered with some first rate photography and editing, it is a beautifully put together film which is topped off by some fine performances from the ensemble cast. However, a little more fact and a little less facetiousness would have not gone amiss.

Opinions about the merits of *The Right Stuff* remained sharply divided at the time of its release: critics every-

Letter To Brezhnev

comedy in which a small boy befriends a mouse and a dog which have landed in a Russian satellite. Later on in the film he is invited to the Soviet launch site and then is accidentally launched in space.

A little more intriguing was the 1967 Spanish/Italian co-production *Dos Cosmonautas a la Fuerza* [Aggata Films/IMA Films]. Predating *Capricorn One* by a full decade, the picture begins with the launch of a pair of cosmonauts in an attempt to reach the Moon.

When contact with the capsule is lost the Soviets secretly launch a pair of look-alikes on a short duration flight so that they can be meretriciously paraded in front of the world as the first men on the Moon. However, the deception unravels when both crews return to Earth successfully.

In both cases the lack of accurate information about the Soviet space programme was advantageous, in as much as it allowed the film-makers a greater degree of artistic licence (audiences naturally had fewer pre-conceptions of what to expect). However, an over dependence on parochial satire means that the finished products ended-up being unnecessarily half-hearted.

where showered it with laudatory reviews; audiences stayed away in droves. *The Right Stuff* was widely tipped to sweep the Oscars [9] and maybe even push John Glenn in the direction of the White House. In the event, both parties were disappointed. *The Right Stuff* and its neophyte astro-voyagers was beaten for the top prizes by *Terms of Endearment* [Paramount, US, 1983], which featured Jack Nicholson as a drunken, pot-bellied ex-astronaut. As for Glenn, he did not even step into the same ring as former actor Ronald Reagan in the race for the Presidency.

Guilty By Suspicion

As the great American film producer Sam Goldwyn once said "Pictures are for entertainment, messages should be delivered by Western Union". This probably speaks volumes about the mentality of the average Hollywood movie mogul, for all but the most unsophisticated cinemagoer would agree that movies can play an important role in shaping public opinion. Unfortunately, the messages sent out by most movies featuring the space programme have been pretty defiling and have presented a rather shallow view of this great endeavour. At one extreme the Space Shuttle resembles

a proto-Millennium Falcon, jetting around low Earth orbit virtually at will (*Moonraker*, *Starflight One*); while at the other extreme NASA is portrayed as being manipulative and gung-ho (*Countdown*, *Capricorn One*).

It is often said that there is no such thing as bad publicity, but when you see a film like *Capricorn One* risibly being aired on TV as part of a special season of programmes commemorating the 25th Anniversary of the flight of Apollo 11 it does make you wonder.

It is to be hoped that *Apollo 13* will go at least some of the way to restoring the rather tarnished image of the astronaut on the big screen, but it will be a tall order.

Credits

Not quite a cast of thousands, but nevertheless the writer would like to thank Lee D. Saegesser, Frederick I. Ordway III, Eric Burgess, Andrew Pilkington, Jean-Michel Nadeau and The British Film Institute.

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'Space Movies' Competition

The way that space technology has been portrayed in the movies has been highlighted in this issue with a few examples. Our competition this month gives readers the opportunity to unearth a few more - and perhaps win a prize.

Prizes: The first two correct entries to be opened after the closing date of 2 March 1995 will receive a copy of the book:

'Space Almanac'

by A. R. Curtis

This comprehensive book covers just about everything one may wish to know about space exploration. Published in 1994 by the Gulf Publishing Company, it is distributed by Plymbridge Distributors Ltd, Plymouth, PL6 7PZ and is priced at £30.99 (hardback), £21.99 (paperback).

To Enter: Answer A, B, or C to each of the following three questions, using each of these letters once:

1. In which Bond movie does a picture of Yuri Gagarin make a brief appearance ?

A. The Russia House B. Licence To Kill C. From Russia With Love

2. Which villain tried to kill James Bond using an industrial laser which could: "project a spot on the Moon" ?

A. Auric Goldfinger B. Ernst Stavro Blofeld C. Karl Stromberg

3. Chuck Yeager was given a small cameo role in "The Right Stuff". Which of the following did he play ?

A. An Edwards flight mechanic B. A bartender C. A chauffeur for one of the astronauts

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 2 March 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name

Address

.....

.....

European Week of Scientific Culture



Presentations and speeches at the end of the EURISY conference.

Space Weekend for Students and Teachers

During the European Week of Scientific Culture in November 1994, the Euro Space Center played host to the third EURISY conference, a three day meeting for young people and their teachers under the headings *Bringing space into the classroom* and *Europe's teachers faced with the challenge of space*.

The aim of this annual meeting is to give students the chance to meet and talk to space experts and get a practical insight into astronaut training. For teachers, it is the opportunity to take a collective look at the resources for providing appropriate information on space technology and assess the value of integrating remote sensing and space science applications into secondary teaching.

The conference attracted more than 100 students from as far afield as Norway, Poland, Rumania and Hungary in the north and east to Morocco and Tunisia in the south. With sizable delegations from France, Belgium, Germany, Holland and Denmark, it was left to the British Isles to field a token presence - with a single student from Manchester and two from Wales.

The weekend event was supported by the European Commission, giving the opportunity for the organisers to finance the visits of five astronauts and cosmonauts - Claude Nicollier (Switzerland - mission specialist on STS-46 and a member of the STS-61 Hubble servicing mission), Dirk Fritout (Belgium - payload specialist on the ATLAS-1, STS-45 mission), Franco Malerba (Italy - payload specialist on the STS-46, Eureka and tethered satellite mission), Dimitru Prunariu (Rumania - a week on the Salyut 6 space station in 1981) and Vladimir Remek (Czechoslovakia - Salyut 6 in 1978).

BY CLIVE SIMPSON

BIS Member

Looking to the Future

Astronaut Franco Malerba, now a European parliament MP, told students: "We are building incredible things with high technology, we are thinking and investing for a new society, where computers, communications and high technology are building a new revolution in our society - and you will be part of it, you will be the

driving force.

"It is very necessary to collate the exploration message with the message of discipline, of management of human knowledge, of concern about the environment, and of merging things which come from different disciplines in order to move our society forward".

During this early part of the proceedings, students had the opportunity to hear presentations from other astronauts and cosmonauts and ask their own questions.

School Projects Exhibited

The fact that much practical work related to space is already taking place in schools throughout Europe was ably demonstrated at a special exhibition put on by students of their school and college work in the past year.

Prizes were awarded to those judged the best, with the overall winners - from Denmark - receiving a trip to the Ariane launch centre in French Guiana for their high quality presentation of the practical application of remote sensing data. In other categories, younger students representing schools in Llanelli, Wales and Lettonie, Latvia, received laptop computers for their excellent efforts.

Student Zoe Negus (17), from Withington Girls' School, Manchester, described the weekend as an excellent way of meeting other like-minded students from all over Europe. "I am hoping to study physics and astrophysics and this has really been a lot of fun", said Zoe, as she waited her turn on the multi-axis demonstrator during a morning of practical activities.

Space in Education and Politics

Speaking at the close of the conference, the Belgian space minister, Jean-Maurice Dehousse, described

Manchester student Zoe Negus is strapped into the multi-axis chair.





A Europa II rocket which was built but never flew rests outside the entrance to the Euro Space Center, Belgium.



Students Matthew Davies and Timothy Davies, from Llanelli, Wales, take the seats of commander and pilot in the shuttle mission simulator.

space as an "immense motivation" for the human mind on the "border of the 21st century".

"Space brings us together, especially in Europe. Space is a challenge. It is a challenge for the young, it is a challenge for teachers, and it is a challenge for politicians, who are responsible for the allocation of money. As we are on the threshold of the 21st century we must see all what space has done and we must think even more of what space can do", he said.

Mr Dehousse urged people to make a "real effort" so that space does not just remain an unattainable ideal. "We must realise the dreams of space,

space research and space exploration, and we must explain to the man in the street what science and technology has made possible not only for the next generation of space research but for the benefit of everyone".

But he warned: "It is very easy to convince young people. It is much more difficult to convince older people that space can bring something, not only to mankind in general, but to them in their everyday lives. I think we have done a lot, but much remains to be done."

"Space is a challenge not only for the big countries but also for small countries like Belgium. It is very important in democratic terms that space should not belong to one country or set of countries, which by their size, by their strength, by their wealth consider space as a monopoly", he said.

Mr Dehousse spoke of his frustration over the development of an international space station. "We have been discussing the possibility for many years but I do not have the impression that we have made significant progress. It remains an objective but it seems just about as distant as five or six years ago. We move but the station moves away from us and I believe that the European space ministers who meet in 1995 will have a difficult meeting on this issue."

Astronauts and cosmonauts field questions from young people and teachers. From left: Franco Malerba, Claude Nicollier, Dimitru Prunaru, Vladimir Remek and Dirk Frimout.



About the Euro Space Center

At first glance the beautiful Ardennes region of south-east Belgium is an unlikely location for the Euro Space Center. Even more so because the centre is the prodigy of the high-tech Italian company, CIZET.

Set in the heart of some of Belgium's most beautiful countryside, it is a place of awe and inspiration for hundreds of students from around Europe who visit it each year. Here is a place where they see not only the great space exploits of the past and present, but where they also get as close as possible to the real experience of being an astronaut.

The Euro Space Center, opened three years ago, works on two levels - as an exhibition and visitor centre where members of the public can visit and get a guided tour. And, as a space camp for students, who can spend anything from one day to a week on courses and training exercises.

Euro Space Camp - a franchise operation of its big brother in the United States - is primarily for young people between the ages of 10 and 18. Accommodation is provided in two single-sex dormitories catering for 146 at any one time.

Director Ivan Mariami says he is not creating "just another attraction park" but a very real space centre. For example, none of the students goes on the training aids until they have completed theoretical lessons.

As well as a full size mock-up of a space shuttle, a mission control centre and shuttle simulator, there are a variety of devices for simulating work in zero-g, including an eight metre deep water tank.

Last year Euro Space Center - which cost around £10 million to develop and open - attracted over 100,000 visitors and it predicts that the 1994/95 season will see it break even for the first time.

But a final point. If you are thinking of visiting from the UK brush up on your French and Dutch first. Although students benefit from sessions in English, tours for the public do not and none of the labelling in the exhibition is in English either. A minor shortcoming perhaps considering the low number of visitors from the UK at present, but surely something to change for the future?

Fact File

Address: rue devant les Hetres,
1-6890 Redu-Transinne,
Belgium
Tel: (0) 61 65 64 65
Fax: (0) 61 65 64 61
Location: Close to motorway E411 (exit 24). Nearest railway station - Libramont (Brussels/Luxembourg line).
Facilities: Self-service restaurant, small souvenir shop.
Admission: 395 BF (approx £8) with a small reduction for children.

All photographs by the author.

Students Test Orientation Device

Two students from the University of Kent at Canterbury, Hajime Yano and Wayne Brooke-Thomas, had a unique opportunity last December to carry out various experiments on a device called the Fluid Coil Actuator which is designed to orientate astronauts freely-floating in space. The experiments were not actually undertaken in space but on board a specially designed aircraft which enabled microgravity to be experienced.

The parabolic flights were won as a prize in a competition run by the European Space Agency and RSV Ruimrevaartdisput (Spaceflight, September 1994, p.304). The aim of the competition, which was open to all European universities, was to enable students to actually put into practice proposals they had submitted as their competition entry.

Both students had to pass rigorous medicals as the flights were physically arduous. As Hajime explained, one reason for this is the way in which microgravity conditions are achieved. For each parabola, the flight path took them from normal gravity (1G) to twice normal gravity (2G) and so to microgravity. Each gravity condition lasted 20 seconds. They then experienced the same in reverse. After two flights Hajime had experienced a total of 44 parabolas. Whilst this provided him with nearly 15 minutes of microgravity, it also meant he had to endure around 30 minutes of 2G.

The work carried out on the flights enabled the students to confirm that their system worked in microgravity conditions. However, they encountered problems because they had to share the small cabin area with 16 other experimenters, four journalists and the support team. "In this experiment it is essential not to touch anything. It needs to be a totally closed system, otherwise a new force enters the system and the conservation of angular momentum is spoiled", said Hajime. Despite this, he and Wayne managed to obtain three data sets for three different masses.



Hajime Yano floats on board a Caravelle flight.

ESA

The next stage is for Hajime and Wayne to produce a video for use by A-level physics students. They are going to work on this with pupils from Canterbury High School who also helped them prepare for the flights.

The European Space Agency is planning to hold a post-flight conference in 1995 to enable those who took part to discuss their findings. Hajime and Wayne received financial support for their work from the following: University of Kent Mastercard Grant, British National Space Centre, Canterbury Rotary Club, Eurotunnel and Crewsaver. ■

Fundamentals of Space Systems

V.L. Pisacane and R.C. Moore, Oxford University Press, Walton Street, Oxford, OX2 6DP, 1994, 772pp, £65, ISBN 0-19-507497-1.

This book is multi-disciplinary in nature and aimed at those interested in space instruments and space systems and sub-systems. The intent is to expose the reader to the underlying scientific and engineering foundations, as well as current practices, so a knowledge of calculus, vector analysis, differential equations and classical and modern physics is assumed.

It is based on a series of lectures delivered at the Johns Hopkins University which, collectively, add up to 11 authors with a background of more than 280 years of experience in the subject.

The text was originally intended for graduate students but has now been extended for a much wider audience, though the material is essentially unchanged from earlier versions.

Topics dealt with are related solely to systems engineering but include the space environment and astrodynamics as well. Spacecraft command, control and telemetry are featured,

along with considerations of thermal protection, spacecraft reliability and quality assurance and subsequent mission operations. Matters are covered to a depth which embraces the design of a spacecraft configuration and structure to satisfy a specified set of requirements.

Wernher von Braun: Crusader for Space: A Biographical Memoir

E. Stuhlinger and F.I. Ordway III, Krieger Publishing Co., PO Box 9542, Melbourne, FL 32902-9542, USA, 1994, 392pp, \$42.50, ISBN 0-89464-842-X.

This is a companion volume, containing the textual account, to the illustrated Memoir on the life of Wernher von Braun which was reviewed on p.179 of the May 1994 issue of *Spaceflight*.

The emergence of high-performance, high-precision rockets took place about half a century ago when Wernher von Braun began an energetic and systematic development programme. In 1958 his team launched the first of the Saturn V Rockets which were to send a total of 12 American astronauts to the Moon.

This book is based on a very close personal relationship

which existed between von Braun and the authors, amplified by more than 100 carefully recorded and edited interviews. It is also based on several hundred verbal and written comments on von Braun by people who knew him well, so the result is a volume which features a wealth of background information not normally recorded for posterity.

Altogether, it took the authors 14 years to research and write the book. A great number of those participating in the Apollo programme appear, though to mention them all would have given the book unwieldy proportions.

Von Braun played a major role in creating a public understanding of space. He led a group of experts who wrote a series of articles for *Collier's* magazine in the 1950s detailing the use of Earth satellites and manned

space flight to the Moon and Mars. These were brilliantly illustrated by Chesley Bonestell, and others, and gripped the imagination of many, especially the young.

Particularly poignant is the description about the subsequent move away from the Saturn V and towards the Shuttle. The analogy is drawn of von Braun as a great conductor who suddenly found himself without an orchestra, players, instruments, a concert hall and even minus a music-loving audience.

Although he responded to this with a period of promoting many new space projects, few listened.

Ed: Von Braun was an Honorary Fellow of the Society and Chesley Bonestell received the Society's Space Achievement Medal for his work.

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- STS-63 Photo Preview

Titov Prepares for Mir Rendezvous Mission

After training in the US as Shuttle mission specialist and acting as backup to Sergei Krikalev on the STS-60 mission of 3-11 February 1994, Vladimir Titov is a crew member of mission STS-63 due for launch with orbiter Discovery on 2 February 1995.

A special feature of this mission is the planned rendezvous with the Mir space station. Other activities include the deployment and retrieval of the SPARTAN satellite and a spacewalk. (See *Spaceflight*, January 1995, p.18).

The first shuttle mission to dock with Mir will be STS-71 with the orbiter Atlantis which is due for launch on 24 May.



NASA

STS-63 Crew Patch

Designed by the crew members, the STS-63 crew patch depicts the orbiter manoeuvring to rendezvous with Russia's Space Station Mir. The name is printed in Cyrillic on the side of the station. Visible in the orbiter's payload bay are the commercial space laboratory Spacehab and the Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) satellite which are major payloads on the flight. The six points on the rising Sun and the three stars are symbolic of the mission's Space Transportation System (STS) numerical designation. Flags of the United States and Russia at the bottom of the patch symbolise the cooperative operations of this mission.



Above : Official crew portrait. Left to right (front row) are Janice E. Voss, mission specialist; Eileen M. Collins, pilot; James D. Wetherbee, mission commander; and Vladimir Titov of the Russian Space Agency, mission specialist. In the rear are Bernard A. Harris Jr., payload commander; and C. Michael Foale, mission specialist.

NASA

Below: Vladimir Titov manoeuvres a small life raft during bailout training at the Johnson Space Center's weightless environment training facility in February 1993 in preparation for STS-60.

NASA



Above: Seated in the rear station of a NASA T-38 jet trainer aircraft, Vladimir Titov prepares to take a familiarisation flight. This photo was taken in February 1993 when Titov was in training with Krikalev for STS-60.

NASA

EuroMir-94 Mission

October - November 1994



Chancellor Helmut Kohl communicates with EuroMir via the Matra Marconi Space videoconference system. See overleaf - 'Experiments Aboard Mir'. MMS

ESA Studies Effects of Long-Term Flights

The EuroMir-94 flights began on October 4 (local time) when ESA astronaut Ulf Merbold was launched with cosmonauts Aleksandr Viktorenko and Yelena Kondakova to relieve the crew already aboard the Mir complex. So began a new era of international space cooperation involving extensive European and American use of Mir.

Soyuz TM-20 Crew

On 3 October at Leninsk, the city at the heart of the Baikonur cosmodrome, the prime crew of the Soyuz TM-20 mission was confirmed by the interstate commission in charge of the Mir orbital station as: commander Aleksandr Viktorenko, flight engineer Yelena Kondakova and research pilot Ulf Merbold.

Viktorenko and Kondakova, the station's 17th main crew (EO-17), were to stay on Mir for 174 days. Merbold, a German scientist representing the European Space Agency, was to make a flight of 30 days.

The crew then residing aboard the Mir station were Yuri Malenchenko, Talgat Musabayev and Dr. Valeri Polyakov. If the mission goes to plan, two world spaceflight endurance records will be set for both a male (Polyakov) and a female (Kondakova) when Polyakov returns to Earth on 26 March 1995 with Viktorenko and Kondakova. In addition Polyakov will also set an accumulated endurance record in space of over 660 days on two separate missions.

Kondakova is married to veteran Salyut-era cosmonaut Valeri Ryumin who once signed an order banning Soviet female space missions and the couple have an eight-year old daughter Zhenya. Ryumin and Kondakova both work for NPO Energiya the builders and controllers of the Mir orbital complex.

Speaking from behind a glass wall at the pre-launch press conference, Kondakova, dressed in a smart suit, announced that her primary objective

on the mission was to prove that a "woman can do as much as a man".

Viktorenko told the press conference that he was happy to make another extended space mission and the thought of not smoking again for another six-months on the station did not bother him.

Merbold told the gathering that the EuroMir-94 flight was a prerequisite for further cooperation between the European and Russian space agencies. "I have enjoyed the chance to

Baikonur needs cleaning up . . . While the Soyuz TM-20 booster leaves the assembly and test building MTK on the left at 7 am on 2 October 1994, the piles of rusty rubbish in the foreground make it difficult for officials and press to accompany the rocket along the railtrack to the launchpad. Despite the apparent lack of cleanliness and accuracy at the Kazakh launch site, Soyuz TM-20 lifted off at 03:42 am local time on 4 October "as advertised".

PETER SMOLDERS



BY NEVILLE KIDGER, FBIS

Leeds, UK

work here in Russia because it is a unique opportunity to learn how manned space flights are performed here," Merbold said.

The German physicist has already performed two spaceflights on the American Space Shuttle and he was set to become only the second person, following Russia's Sergei Krikalev, to experience both Shuttle and Soyuz launches.

Merbold's Mir mission was designed to study the long-term effects of near weightlessness upon the human body. He had 29 experiments to perform in preparation for the planned cooperation with US, Russia, Japan and Canada on the International Space Station.

Next year, a second EuroMir mission is planned that will last 135 days and will include the first spacewalk by an ESA astronaut. Christer Fugelsang and Thomas Reiter are training for this mission. The European Space Agency has paid out a sum for two space missions to Mir which is reportedly in excess of \$80 million.

Soyuz TM-20 Launch

On 2 October the Soyuz carrier rocket with the TM-20 spacecraft was rolled out from the MTK assembly building to the launch pad, an operation which took just 15 minutes. The pad was the same one from where Gagarin had begun history's first manned space mission on 12 April 1961.

Two hours later the rocket stood upright on the launch pad, the rocket's

EUROMIR ЕВРОМИР

shroud carrying the emblems of the Russian Space Defence Forces (who launch the rockets in Russia) and ESA.

TM-20 was duly launched on schedule into a clear black night sky at 2242 (all times are GMT) on 3 October. (Early in the morning 4 October at Baikonur.) Ground observers, who included the two American astronauts training for a three-month long Mir flight in 1995, Drs Norman Thagard and Bonnie Dunbar, were present and the trail of flame could be followed as the rocket ascended for five minutes.

Soyuz TM-20 was placed into a satisfactory parking orbit, inclined at 51.6 degrees to the equator. Following separation of the spacecraft from the launcher, control of the mission was handed over from the Space Forces in Baikonur to the Flight Control Centre (TsUP) at Kaliningrad, near Moscow. The TsUP is operated by the Central Institute for Machine Building (TsNIMash) and NPO Energiya.

ESA Director General Jean-Marie Luton, who watched the launch from a viewing site less than one kilometre away, said "The EuroMir programme will put us in a strong position for the development of ESA's own manned spacecraft and our contribution to the International Space Station".

A dual firing of the Soyuz engine some hours after the launch placed it in the correct orbit from which to close in on the Mir complex.

ITAR-TASS announced that, at 1855 GMT on 5 October, the Progress M-24 cargo ship - which had been the cause of so much concern during the latter part of August - was undocked from the Mir complex's front docking port and was later de-orbited and destroyed, as planned, in the upper layers of the Earth's atmosphere.

TM-20 Docking Problems

On 4 October, ITAR-TASS announced that TM-20's docking with Mir was expected at 0022 GMT the next morning.

After two days of gradual approaches and engine manoeuvres the TM-20 craft was in close proximity to Mir at midnight 4 October. Commander Viktorenko and flight engineer Kondakova approached Mir manually after automatic systems brought the Soyuz to within 150 metres of the orbiting complex at 0005 GMT.

At that point the Soyuz's computers "interrogated" the major systems in preparation for the docking approach. But, contrary to expectations, the craft began to yaw causing the computer's "angles of divergence" to

be exceeded. Viktorenko began to receive emergency warnings on his control board.

After a rapid exchange of views with Flight Director and veteran cosmonaut Vladimir Solovyov, Viktorenko switched the systems over to manual control and flew the final approach using his control lever.

The approach began at 0020 and Viktorenko, with Kondakova's assistance, used the small manoeuvring jets of Soyuz to control the unexpected yaw. Docking took place eight minutes later, at 0028 GMT, some 6 minutes later than planned as it passed over China on its 34th orbit.

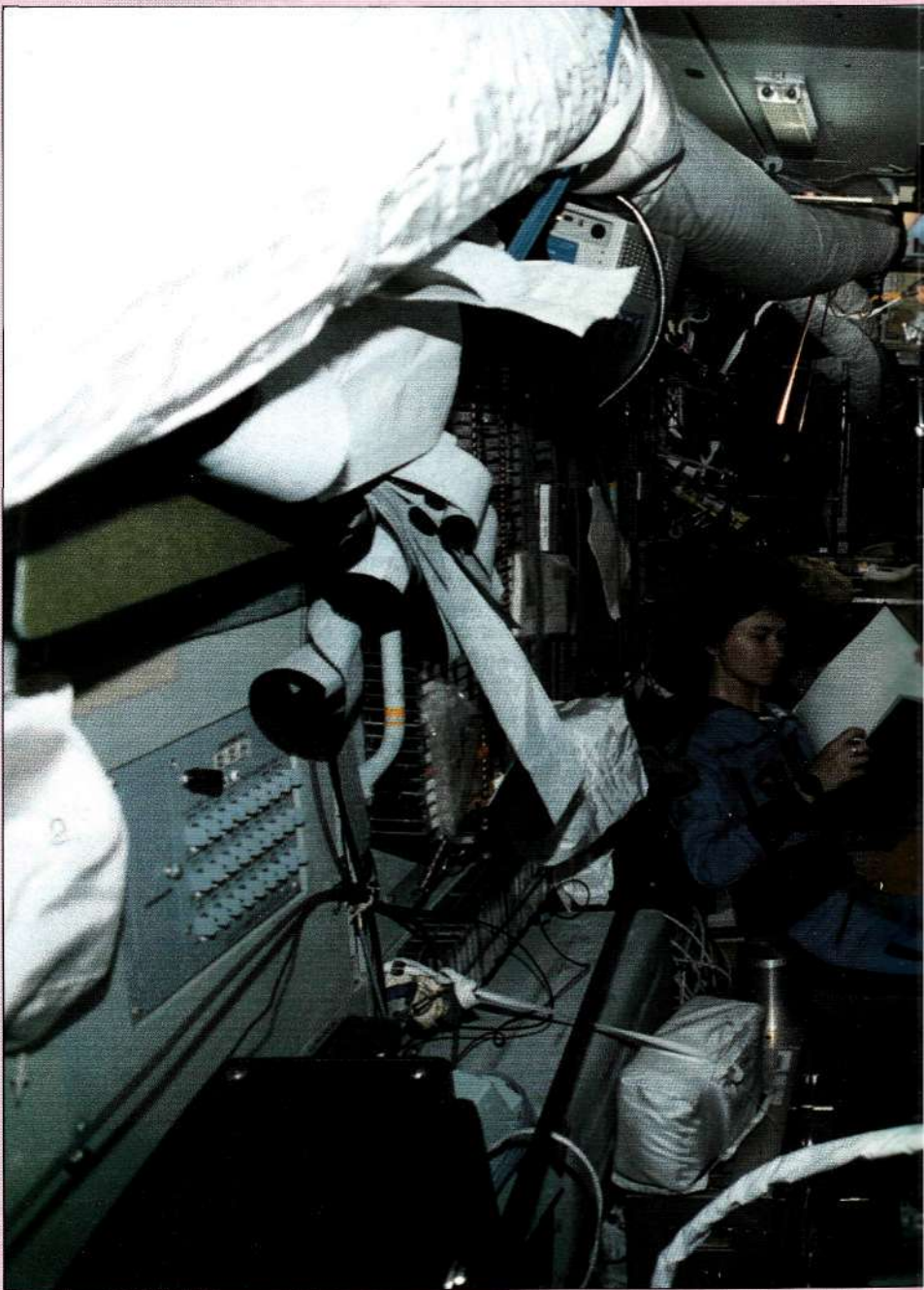
After checking that the connection with Mir was airtight, the TM-20 crew

took off their pressure suits, opened the hatch and floated into the station about an hour after the docking. They were welcomed by Yuri Malenchenko, Talgat Mussabayev and Valeri Polyakov.

Shortly afterwards, ESA Director General Luton, Russian Space Agency chief Koptev and NPO-Energiya President Yuri Semenov congratulated the crew in a live-link from the mission control centre at Kaliningrad, near Moscow.

Members of the German press corps were also able to speak with Merbold, whose wife and family had watched the docking at the TsUP.

With the successful docking, the EuroMir-94 mission began in earnest.



Daily activities on Mir with Yuri Malenchenko, co

events on the station.

Power Problems

On 12 October, the Russian Interfax news agency reported that Mir was experiencing serious power supply problems. It transpired that on 11 October the crew had been forced to switch off the station's automatic control and navigation systems for a period due to an overload on the internal power cells "caused by intensive work of its life-support and air cleaning units." The station's life-support system was designed to cope with just five people and there were six aboard. To bring power levels back the TsUP had to order disconnection of some of the station's energy intensive equipment. By 12 October six of the 12 batteries were on-line again.

The next day Radio Russia reported that the complex's solar arrays had been turned away from the Sun and that, the cosmonauts had only managed to align them to face the Sun by manoeuvring the station with the Soyuz TM-19 engine.

Following the successful realignment of the solar panels power began to flow again to the batteries and the cosmonauts were able to start up a reserve computer system enabling them to regain control of the station's orientation. The batteries were then able to be recharged and by midday on 13 October it was reported that the power had reached 60% of normal. The TsUP spokesman announced that seven of the 12 batteries had been recharged.

During the power problems Ulf Merbold and some of his colleagues had continued the research programme and an official announcement was made to deny media reports that there had been a plan to return part of the station's crew to Earth earlier than planned. However, the cosmonauts were reportedly forced to control the orientation of the station by manual means on a continuous basis to ensure that the solar arrays pointed towards the Sun.

By 14 October Malenchenko and Musabayev managed to replace three accumulator batteries in the base block. These were stated by ITAR-TASS as the cause of the electrical supply system malfunction and by 18 October the work to restore the normal functioning of the electric system had been completed. Also by 18 October, the EuroMir-94 mission was half over.

Speaking later, Yu. P. Antoshchkin, a deputy chief of the TsUP said that the orientation problems had been "rather dramatic" with contact being lost with the station for four and a half hours and subsequently no information being received about the crew's well-being.

An ESA news release conceded that EuroMir project officials had had to reschedule some of their experiments



commander of the Mir main crew, in the foreground.

ESA

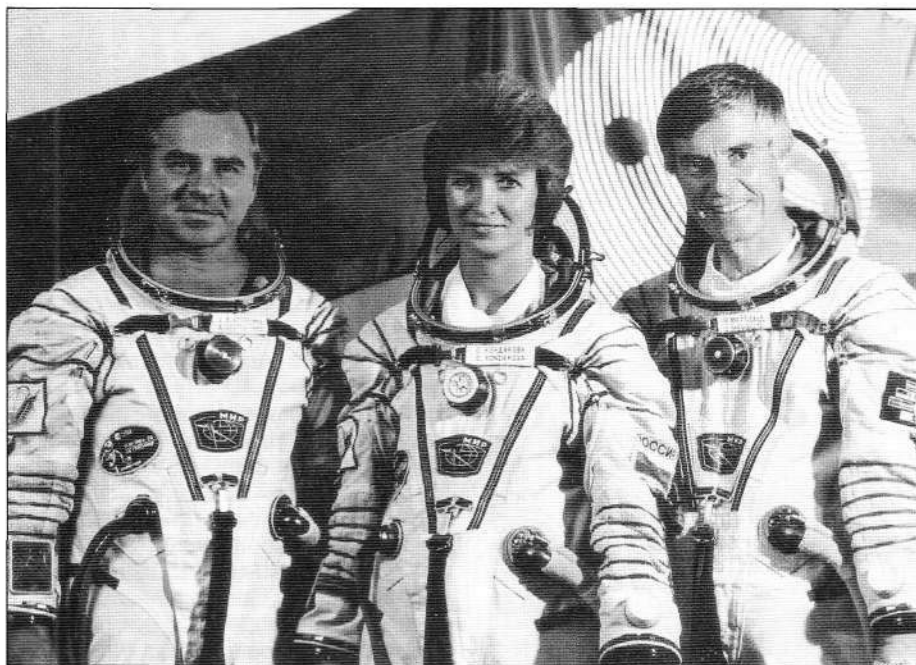
Experiments Aboard Mir

The scientists in Europe behind the 29 experiments to be performed by Merbold were able to monitor in-orbit activities via a satellite video conferencing system, known as DICE, developed by ESA and supplied by Matra Marconi Space. The system was also used for the AustroMir mission which flew in 1991.

The system allows multi-way video and audio communication by linking the mission control centre and the space station itself to ESA's ESTEC establishment in the Netherlands; the European Astronaut Centre in Germany; the agency's headquarters in Paris; and centres at CNES in France and DLR in Germany.

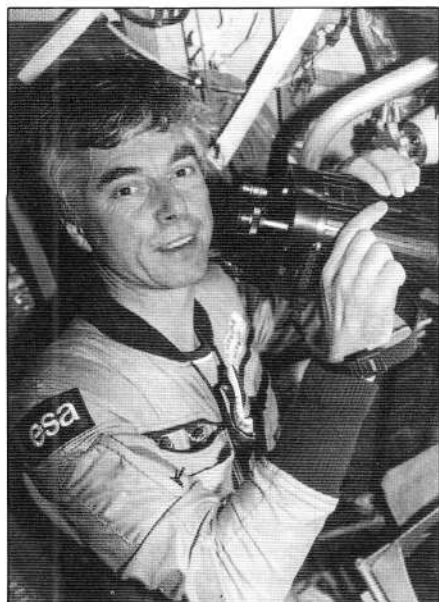
There was about 20 minutes of live video per day from the station in addition to the voice and data links. For long periods because of the lack of worldwide or orbital relay facilities the station was out of radio and video contact with the TsUP.

On 10 October the six cosmonauts on Mir and the German Chancellor Helmut Kohl took part in a live TV link-up. Kohl said that Germany looked forward to participating in the creation of the International Space Station as a part of ESA and that Merbold was "a living example of the possibility of global cooperation", citing the astronaut's previous flight aboard the US shuttle. But the political side of the mission was soon to be overtaken by



EuroMir-94's official crew portrait (left to right): Aleksandr Viktorenko, Mission Commander; Yelena Kondakova, Flight Engineer; Ulf Merbold, Research Cosmonaut.

TsPK for ESA



During one of his free moments Ulf Merbold enjoys viewing the Earth through binoculars. ESA

on 11 October due to the power shortage aboard the station. Russian officials said that the problem was a consequence of video and photographic activities, which used power consuming lights, combined with the recharging of batteries aboard the docked Soyuz TM-20 spacecraft and high power demands by the station's on-board systems.

With experiments rescheduled, ESA scientists expected to complete their investigations as planned. "The mission is back on track and the science programme is going well", said Wolfgang Nellessen, EuroMir Project Manager. "The crew is healthy and we are looking forward to two more weeks of productive work". Merbold was tak-

ing at least an hour's exercise a day to help counteract the effects of weightlessness. Merbold and his Russian colleagues were in good health, according to Dr. Valeri Polyakov.

As part of the science programme, Merbold and the cosmonauts took regular saliva, urine and blood samples for post-flight analysis. Body mass, skin thickness and muscle measurements were also made, but materials science experiments were postponed until later in the flight because of their high power consumption.

"Space Class"

On 19 October, 45 European school children participated in a live link-up

with the station from ESA's Research and Technology Centre, ESTEC in the Netherlands. During the 30-minute "space class", Merbold gave an explanation of his mission and gave an insight into living and working in space.

The video link was made through the DICE system. Merbold also used the DICE system to "call home" and speak to his family on the weekend of 15-16 October. Such private family contacts are considered important on long-duration flights.

Science Experiments Halted

Four materials processing experiments were on the EuroMir-94 flight plan utilising the Czech-made CSK-1 furnace, plus one evaluation of a computer monitoring task. However, because a crucial furnace aboard the station had failed, these five materials sciences experiments were left to be conducted at a later date by Russian cosmonauts.

Extensive efforts to repair the furnace, which has been aboard the station for many years, were abandoned and spare parts needed to repair the furnace will be shipped to the station on a Progress cargo spacecraft. The results of the materials sciences experiments could then be returned to Earth next summer aboard the US shuttle after it docks with Mir.

On 28 October, Merbold passed the longest flight time by a West European (beating the record set by Frenchman Jean-Loup Cretien in 1988).

Dr Polyakov carried out cardiovascular examinations of Malenchenko and Musabayev during sessions in the Chibis leggings (to simulate the pull of gravity by negative pressure). Such tests are routine for cosmonauts returning from a long flight. The leggings help cosmonauts to recondition their body for the return to Earth's gravity.

Valeri Polyakov, a medical doctor, finishes one of the many space medical experiments with Ulf Merbold (left). ESA





In the base block of Mir at the time of a TV transmission. Left to right: Taldat Musabayev, Ulf Merbold and Yelena Kondakova. ESA

On 1 November Malenchenko and Musabayev completed the biotechnical experiments Biocryst and Maksat, and prepared packages with the results of their experiments for return to Earth. The pair also held more sessions in the Chibis leggings. Merbold continued to concentrate upon medical tests and the trials of a Lepton computer.

Flight Plan Changes

On 2 November the crew of Soyuz TM-19 was assigned a new task - to test the efficiency of the Kurs approach and docking system. This would involve the undocking of the craft from the Kvant astrophysics module, then performing trial approaches and a mooring. The unscheduled test meant that the return of Malenchenko, Musabayev and Merbold was to be delayed by one day to 4 November.

The Kurs system was to be used in future resupply flights to the station and the test followed the problems experienced by the docking of the Progress M-24 cargo ship and Soyuz TM-20.

The plan for the test involved the cosmonauts in Soyuz TM-19 filming the docking system and, in the event of a failure to re-dock, returning to Earth.

TM-19 Redocking

On November 2, at 1030 GMT with cosmonauts Malenchenko, Musabayev and Merbold aboard, the Soyuz TM-19 craft was undocked from the Kvant module and backed away from Mir to a distance of 190 m. By locking the Soyuz's avionics on to the Kurs system, the craft was commanded to approach the docking port in the auto-

mated mode. A successful approach and docking was completed after 35 minutes of free flight and the Russian managers announced that they were happy with the test.

Before boarding Soyuz TM-19 for the test, the cosmonauts had loaded it with containers of biological samples just in case they had to return to Earth in the event of a failure. With the successful redocking accomplished, the samples were returned to the refrigerator in Mir to be stored until the scheduled return to Earth.

Banner Day for ESA

November 3 proved to be a banner day in the history of ESA's manned space programme because, as Mer-

At 'Space Expo' in the Netherlands, the link-up is awaited with the Mir cosmonauts and particularly with ESA astronaut Ulf Merbold. Seen here is Dutch astronaut Wubbo Ockels relating his own space experiences to an international 'space class' and answering children's questions.

E. RUDOLF VAN BEEST



bold wrapped up his work on the Mir station, another ESA astronaut was beginning his work as a crew member of the STS-66 Space Shuttle mission.

Jean-Francois Clervoy was launched at 1659:43 GMT on 3 November with five Americans for a scheduled 11-day mission to study the Earth's atmosphere with the ATLAS-3 science payload containing major European equipment. (*Spaceflight*, January 1995, p.16).

Return of Soyuz TM-19

The Soyuz TM-19 craft with Malenchenko, Musabayev and Merbold aboard was undocked for the second and final time at 0729 GMT on 4 November after the cosmonauts had bidden farewell in a televised ritual to the crew they were leaving behind.

Valeri Polyakov became the first person to have three separate commanders during a single space flight.

Soyuz TM-19 landed at 1118 GMT, some 79 km NE of the town of Arkalyk in Kazakhstan and about 9 km from the target spot.

The landing was later described as "rough" by Malenchenko because strong winds had caused the capsule to "bounce" and come to rest only on its second contact with the Earth; but there were no injuries.

The three cosmonauts were helped from the capsule by recovery personnel just minutes after landing. They were seated in lounge chairs and gave an impromptu conference for journalists. The crew were joined for photos by the President of Kazakhstan, Nursultan Nazarbayev.

The Kazakh leader became only the third head of state to greet a returning the space crew. The previous leaders were Richard Nixon (Apollo 11) and Ronald Reagan (STS-4) of the USA.



The Soyuz TM-19 spacecraft after landing in Kazakhstan on 4 November 1994. Ground support crew members are waiting and ready to assist Ulf Merbold, Yuri Malenchenko and Talgat Musabayev to leave the capsule.
P. AVENTURIER FOR ESA

New Progress Launched

On 10 November ITAR-TASS announced that the next cargo ship, Progress M-25, was scheduled for launch at 0722 the next day by a Soyuz-U launcher from Baikonur. It was to be the first of two cargo ships to resupply the EO-17 crew, the second being in February 1995.

Progress M-25 would deliver over two tonnes of consumables to the cosmonauts as well as a Raduga ballistic return capsule to allow the return of about 150 kg of experimental results to Earth.

Launch was on schedule on 11 November and ITAR-TASS gave details of the launch: first stage separation occurred 108 seconds after launch at a height of 49 km; the nose fairing was jettisoned at a height of 84 km; 109 seconds later the second stage separated at a height of 167 km and 529

From left to right: Yuri Malenchenko, Talgat Musabayev and Ulf Merbold relaxing amidst members of the recovery team. The crew were joined by the President of Kazakhstan, Nursultan Nazarbayev.
P. AVENTURIER FOR ESA



seconds into the flight the unmanned cargo ship separated from the third stage and was placed into an orbit of 193 x 245 km.

After two days of manoeuvres to catch up with the complex, the Progress craft docked in an automatic mode without incident with the rear Kvant port at 0904 on 13 November and the crew began unloading the cargoes just a few hours after the docking.

Future Mission

Following the postponement of the launch of the first of two new science modules, Spektr, the flight plan for Mir's 17th main crew underwent a radical overhaul. The planned launch for Spektr is now 10 May 1995. Another module, Priroda, is due for launch on 11 June (see p.66).

Aleksandr Viktorenko, Yelena Kondakova and Dr. Valeri Polyakov remain scheduled to return to Earth on



Ulf Merbold walks away from the Soyuz capsule supported by members of the recovery team.
P. AVENTURIER FOR ESA

March 26 1995 but EVAs planned for Viktorenko and Polyakov have been cancelled.

These EVAs were planned for late November to reposition the Kristall module's Reusable Solar Arrays to the Kvant astrophysics module so that the US Shuttle Orbiter Atlantis can dock with the complex later this year.

Any impact on US shuttle missions due to visit the station is currently unknown although there was to have been over one tonne of US equipment on the delayed Spektr module. Some of this equipment was to have been used by Dr. Norman Thagard during his planned 3-month long mission to Mir which is still scheduled for launch in March 1995.

Our grateful thanks are due to Rolf H. Schoevaart, the Netherlands for supplying the ESA photographs on pp.54-58; and to J.K. Andersen, Denmark for assistance with other ESA information concerning EuroMir-94.

Mir Experiments: Details Revealed

ESA's EuroMir-94 experiments provided a full programme of activities for Ulf Merbold. There were a total of 29 experiments of which all but seven were in support of life science, the rest being in support of materials science and the application of certain technological devices.

In contrast to other Mir experimental schedules, the ESA work has been documented in a simple explanatory form and made openly available for the benefit of interested parties. For each experiment, a few concise paragraphs provide answers to the questions:

What is studied?
Why is this done?
How is this done?

For some experiments, notes are added to say what results are expected. Given here is limited information in the form of descriptive titles of experiments and the names and addresses of their principal investigators from whom further details may be obtained.

Life Science

Circadian rhythms and sleep during a 30-day space mission: Dr A. Gundel, DLR Institute of Aerospace Medicine, 51140 Cologne, Germany.

Fluid and electrolyte balance during weightlessness and possibilities of their regulation: Ch. Drummer, DLR Institute of Aerospace Medicine, D-511 40 Köln, Germany.

Magnetic resonance spectroscopy and imaging of human muscles before and after space flight (Ground Experiment): Dr J. Zange, DLR Institute for Aerospace Medicine, 51140 Cologne, Germany.

Radiation health during prolonged space flight: Dr G. Reitz, DLR Institute for Aerospace Medicine, Biophysics Division, Linder Höhe, 51147 Köln, Germany.

Chromosomal aberrations in peripheral lymphocytes of astronauts (Ground Experiment): Prof Dr Gunter Obe, University-GH Essen, FB 9, Dept of Genetics, POB 45 037, 45117 Essen, Germany.

Fluid shifts into and out of superficial tissues and tissue stability along body axis under microgravity conditions in man: Prof K. Kirsch, Dept of Physiology, Free University Berlin, Arnimallee 22, 14195 Berlin, Germany.

Effects of changes in central venous pressure on the erythropoietic system under 1-g and microgravity (Ground Experiment): Ch. H. Gunga, Dept of Physiology, Free University Berlin, Arnimallee 22, D-14195, Berlin, Germany.

Spatial orientation and space sickness: Prof H. Mittelstaedt, Max-Planck Institut für Verhaltensphysiologie, D-82319 Seewiesen, Germany.

Posture and movement: A. Berthoz, Laboratoire de Physiologie de la Perception et de l'Action, CNRS - Collège de France, 15 rue de l'Ecole de Médecine, 75270 Paris, Cedex 06, France.

STAMP (Spatial, Temporal And Mental Process): A. Berthoz, Laboratoire de Physiologie de la Perception et de l'Action, CNRS - Collège de France, 15 rue de l'Ecole

de Médecine, 75270 Paris, France.

Space flight related orthostatic intolerance: Role of autonomic nervous system, water balance, volume regulating hormones: Prof C. Gharib, Laboratoire de Physiologie de L'Environnement, Faculté de Médecine Grange-Blanche, 8 Avenue Rockefeller, 69373 Lyon Cedex 08, France.

Changes in mechanical properties of human muscle as a result of space flight (Ground Experiment): F. Goubel, Université de Technologie de Compiègne (UTC), URA CNRS 858, BP 649, F-60206 Compiègne Cedex, France.

Bone mass and structure changes and bone remodelling in space: Prof C. Alexandre, Laboratoire de Biologie du Tissu Osseux, Faculté de Médecine, 15 rue Ambroise Paré, 42023 Saint Etienne Cedex 2, France.



Influence of space flight on energy metabolism: Dr V. Demaria-Pesce, CNRS UA 637, Laboratoire de Neurobiologie des Régulations, Collège de France, 11 Place Marcelin Berthelot, 75231 Paris Cedex 05, France.

Adaptation of basic vestibulo-oculomotor mechanisms to altered gravity conditions: H. Scherer, Universitätsklinikum Steglitz, Free University Berlin, HNO Klinikum, Hindenburgdamm 30, D-14059 Berlin, Germany.

Gastroenteropancreatic peptides during microgravity and their possible involvement in space motion sickness: Dr R.L. Riepl, Klinikum Innenstadt der Universität München, Medizinische Klinik, Division of gastroenterology, Ziemssenstrasse 1, D-80336 München, Germany.

Non-invasive stress monitoring in space

flight by hormone saliva measurement: Dr C.J. Strasburger, Medizinische Klinik, Klinikum Innenstadt, Ludwig-Maximilians-Universität, Ziemssenstrasse, 80336 München, Germany.

Otolith adaptation to different levels of gravity (Ground Experiment): W. Bles, TNO Institute for Human Factors, PO Box 23 3769 ZG Soesterberg, The Netherlands.

Effects of microgravity on the biomechanical and bioenergetic characteristics of human skeletal muscle (Ground Experiment): P.E. di Prampero, Università Degli Studi di Udine, Dipartimento di Scienze e Tecnologie Biomedicine, Sezione di Fisiologia Umana, Facoltà di Medicina e Chirurgia, Via Gervasutta 48, I-33100 Udine, Italy.

Influence of microgravity on osmo- and volume regulation in man: Dynamic response to isotonic and hypertonic loads: Dr P. Bie, University of Copenhagen, Dept Medical Physiology, Panum Inst., Blegdamsvej 3, DK-2200 Copenhagen, Denmark.

Correlation of eye torsion changes with the time course of the space adaptation syndrome: C.H. Markham, S.G. Diamond, Department of Neurology, UCLA, School of Medicine, Los Angeles, CA 90024-1769, USA.

Immune changes after space flight: Dr Didier Schmitt, Laboratoire d'Immunologie, CHU Rangueil, 31054 Toulouse Cedex, France.

Materials Science

Liquid-Liquid phase separation in glasses by microgravity: Dr H. Reiss, Otto-Schott-Institut für Glaschemie, Chemisch-geowissenschaftliche Fakultät, Friedrich-Schiller-Universität, Fraunhoferstrasse 6, 07743 Jena, Germany.

Research on bulk metallic glasses: Prof H.J. Fecht, Institut für Metallforschung/Metallphysik, Technische Universität Berlin, Hardenberg 54.36, D-10623 Berlin, Germany.

Thermophysical properties of undercooled melts: Dr R. Willnecker, DLR Institut für Raumsimulation, D-51140 Cologne, Germany.

Reaction and solidification behaviour of in-situ metal matrix composites: Prof L. Froyen, Department of Metallurgy and Materials Engineering (MTM), Katholieke Universiteit Leuven, de Croylaan B, 3001 Leuven, Belgium.

Technology

Crew Support Computer Experiment (CSCE): B. Svensson, Columbus Utilisation Support Development Office, European Space Agency/ESTEC (GID), Postbus 299, 2200 AG Noordwijk, The Netherlands.

Crew Support Devices Experiment (CSDE): B. Svensson, Columbus Utilisation Support Development Office, European Space Agency/ESTEC (GID), Postbus 299, 2200 AG Noordwijk, The Netherlands.

MICrogravity MAss Spectrometer (MICMAS): W. Riedler, Institute of Communications and Wave Propagations, Inffeldgasse 12-8010 Graz, Austria. ■

STS-68 Mission Report

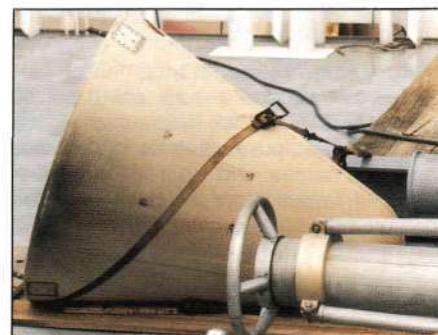


Payload Preparation

Left: In the Operations and Checkout Building on 28 June 1994, the Space Radar Laboratory-2 is being transferred into the payload canister transporter for transfer to the Orbiter Processing Facility for reinstallation into Endeavour's payload bay.

NASA

Recovery



The nose cone of STS-68's right-hand boost was brought aboard the 'Liberty Star' recovery ship. This picture was taken the day after launch as the ship entered the Port Canaveral lock. Nose cones are not always recovered.

PETER GUALTIERI/WEST KENTUCKY NEWS



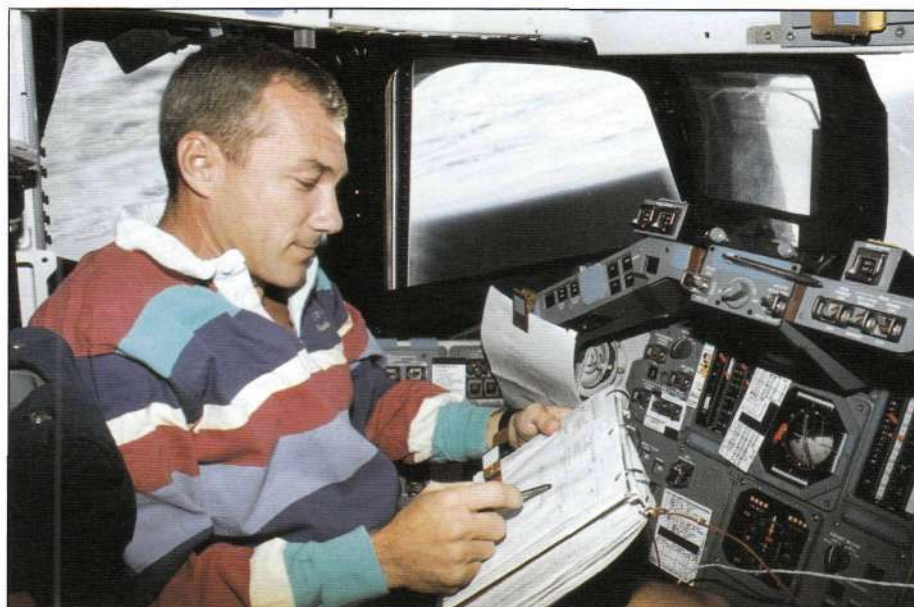
The right-hand frustum of STS-68 showing the spent separation motors.

PETER GUALTIERI/WEST KENTUCKY NEWS

On-Board View

Left: Pilot Terrence Wilcutt consults a procedures manual prior to firing one of the Reaction Control System (RCS) thrusters.

NASA





It is either breakfast or dinner for the STS-68 astronauts according to which team ("red" or "blue") they are members of. From left to right are Daniel W. Bursch, Terrence W. Wilcutt, Michael A. Baker, Thomas D. Jones, Peter J.K. "Jeff" Wisoff and Steven L. Smith. NASA

STS-68

Endeavour

Orbital Flight:

30 September - 11 October
1994

BY ROELOF SCHUILING
at The Kennedy Space Center

For the first time in the Shuttle programme an orbiter was launched carrying the same payload as it had carried on its previous mission. Endeavour's STS-59 launch on 9 April 1994 carried the Shuttle Radar Laboratory payload, SRL-1. The STS-68 mission carried the same payload redesignated SRL-2 in order to study seasonal changes of vegetation and other surface details.

Payload Preparation

Following the STS-59 landing on 20 April 1994 Endeavour was towed into the Orbiter Processing Facility (OPF) and postflight operations began. The SRL-1 was removed from the payload bay and returned to the Kennedy Space Center's Operations and Checkout building on 9 May. While there the payload, now SRL-2, underwent subsystems and radar antenna tests and inspections. On 29 June SRL-2 returned to the OPF and was reinstalled in Endeavour's payload bay. In early July the payload and orbiter underwent tests to verify their connecting interfaces would be ready for the flight.

The SRL-2 payload, as did SRL-1, consisted of the Shuttle Imaging Radar-C (SIR-C) instrument which operated in separate C and L band radars with vertical and horizontal polarity; the German and Italian space agencies' X-Band Synthetic Aperture Radar (X-SAR); the Applied Physics Laboratory-Data Processing Assembly (APL-DPA); and the Measurement of Air Pollution from Space (MAPS) instrument. It may be noted that SIR-B

flew on a previous Shuttle in October 1984 and that MAP also flew with it.

While SRL-2 was the same payload as SRL-1, STS-68 did carry several additional scientific payloads. NASA Get Away Special canisters in the payload bay contained experiments dealing with arthropod development, crystal growth, microgravity and radiation effects on diatoms, concrete curability in space, root growth in space, corrosion in space, and solid-liquid interfaces. Endeavour's mid-deck area carried experiments dealing with chromosome and plant cell studies, biological pest studies, cosmic ray effects and protein crystal growth.

Endeavour's Launch Abort

Endeavour and its payload left the OPF on 21 July 1994 and moved to the Vehicle Assembly Building for mating with the Solid Rocket Boosters and External tank. Roll out to launch pad 39A was on 27 July with the goal of a launch on 18 August. Following the usual pad operations Endeavour entered the launch countdown on 15 August and all went well until T-1.9 seconds when an on-pad abort was triggered by the Shuttle's computer system when it sensed a problem with main engine serial 2032, the engine in the number three position.

The Shuttle was moved back to the VAB on 24 August for a change of engines as all three of its main engines had fired prior to the abort. During the period when Endeavour was in the VAB, Space Shuttle Main Engines (SSME) 2012, 2034 and 2032 were replaced with engines 2028, 2033 and 2026. SSME 2032 was fired on a test stand at the Stennis Space Center and the problem that caused the abort was determined to be due to a failure identification based on the High Pressure Oxidizer Turbopump discharge temperature exceeding expected levels.

Second Time Lucky

STS-68, with a new set of main engines, began its return to launch pad 39A on 12 September following the

successful launch of Discovery from launch pad 39B for STS-64 on 9 September.

The second STS-68 pad flow was shorter than the normal Shuttle pad flow as it was not necessary to load hypergolic propellants and a practice countdown was not required. The countdown was picked up on time at 11:00 am on 27 September and proceeded smoothly with the goal of a lift-off at 7:16 am on 30 September.

The flight crew arrived at KSC on the 27 September and underwent briefings and landing training operations. They were divided into a "red" team and a "blue" team to permit mission activities 24 hours-per-day during the space flight. The "red" team was made up of Baker, Wilcutt and Wisoff; and the "blue" team of Smith, Bursch and Jones.

The countdown continued to go well and no unplanned holds were required. Although the weather had been threatening during the days prior to the launch, conditions at KSC were well within specifications for launch.

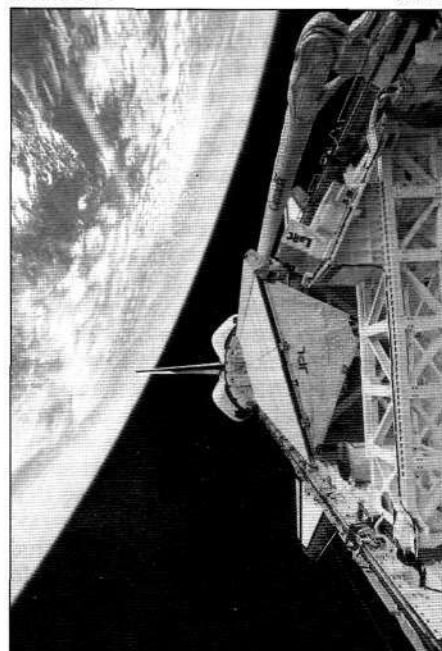
The SSME fired at 7:15:53.459 (SSME 3), 7:15:53.585 (SSME 2) and 7:15:53.703 am, followed by Solid Rocket Booster Ignition at 7:16:00.011 am and Endeavour lifted off on its seventh mission.

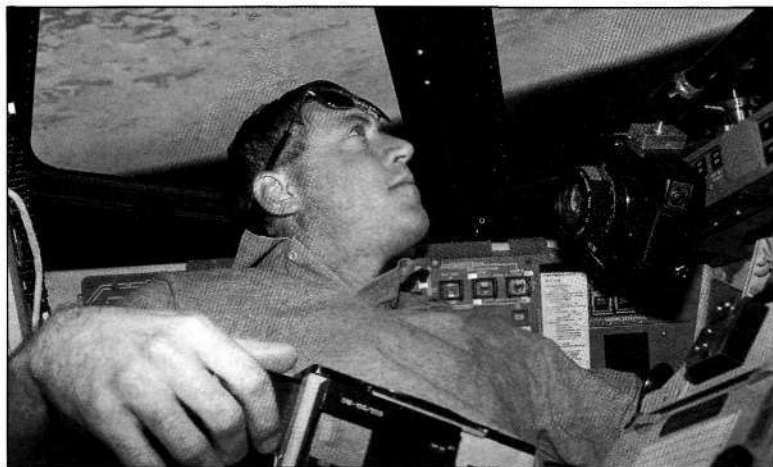
Flight Day One

The ascent phase of the mission proceeded as planned, the Shuttle reaching a 57 degree inclination orbit that was circularised at 119 nautical mile altitude by firing the Orbital Manoeuvring System engines.

The flight crew opened Endeavour's payload bay doors and began activation of the SRL-2 radars. The crew also activated the Get Away Special (GAS)

The Space Radar Laboratory in action as it beams down on the Earth. This picture is a 35 mm frame exposed by one of the crew members. NASA





Michael Baker with camera closeby keeps an eye on the Earth for suitable targets to photograph. NASA

experiment canisters in the payload bay and Pilot Terry Wilcutt conducted operations with the following middeck experiments: Chromosome and Plant Cell Division In Space (CHROMEX), Biological Research In Canisters (BRIC), Cosmic Radiation Effects and Monitor (CREAM) and Commercial protein Crystal Growth (CPCG).

Later in the day Tom Jones sent down video images of the erupting volcano Kiliuchevskoi which is located in Kamchatka. The volcano had begun erupting several weeks previously, however the latest burst had begun only about eight hours after the launch.

Flight Day Two

Environmental studies continued as the six astronauts, working in two shifts, assisted the SRL-2 science team on the ground by providing real-time observations. During the red team operations Commander Mike Baker and Pilot Terry Wilcutt made orbiter attitude adjustments to aid in precise pointing of the radar systems' antennas and Mission Specialist Jeff Wisoff provided a running commentary and tape recorder assistance as SRL-2 studied the many ground target sites. SRL-2 radar images will be compared with those taken on STS-59 by the SRL-1 mission. Data gathered included studies of the desert regions of Africa, mountainous regions of the East and West coasts of the United States and the Atlantic and Pacific Oceans.

Flight Day Three

As with the previous day, radar studies continued during the third day of the STS-68 mission with emphasis on forest areas of North Carolina, ocean current patterns in both the Atlantic and Pacific Oceans, and desert areas in Africa. The data taken during the SRL-1 and SRL-2 missions allow for imaging during two different seasonal conditions in order to study changes in the Earth's environment during the year.

Flight Day Four

Endeavour's payload bay cameras sent down video coverage of the western coast of Oregon and the length of California and the Baja California peninsula that scientists could compare with radar images downlinked from SRL-2 earlier in the mission.

Mission Specialist Jeff Wisoff pinpointed storms, lightning and fires and relayed the information to the SRL-2 science team. His observations helped correlate and corroborate data collected from the science instruments, including the Measurement of Air Pollution from Space (MAPS). MAPS, which was located on the SRL-2 support structure pallet, was used to measure carbon monoxide levels in the atmosphere.

MAPS took special readings of fires which were intentionally set by scientists from the University of Iowa and the Canadian Forest Service. The wind fields and thermal evolution of the fires will be analysed to provide a better interpretation of carbon monoxide emissions from the burning forest and to help calibrate colour infrared photography taken by the STS-68 crew. The fires were planned as part of a forest management programme and were correlated with the mission to take advantage of the opportunity to collect data; however, the fires would have been set even if STS-68 had been cancelled.

Flight Day Five

The STS-68 crew performed two slight manoeuvres to fine tune the flight's orbit, the objective being to fly precisely the same track that STS-59's SRL-1 followed. A trim burn took the orbit to within 30 feet of where it had been in April's STS-59 mission. Using interferometry techniques scientists will be able to develop a three-dimensional comparison of environmental changes during the six months separating STS-59 and STS-68.

Radar images over the Sahara desert and the North Atlantic were taken to help to understand how these areas

affect climates in other parts of the world.

The crew changed their observation plans to train their instruments on Japan following an earthquake in the area. Endeavour passed over the Sarobetsu calibration site and the SAR instrument sent down real-time data of the area that allowed the coastline to be studied for changes due to the tsunami waves associated with the quake.

Routine orbital operations continued with Endeavour now in a 117 by 115 nautical mile orbit as a result of the earlier orbital trim burns.

Flight Day Six

Overnight, the crew reported a missing thermal tile at one of the cabin's overhead windows. The tile apparently came off shortly before the loss was noted as the crew use that window for observations quite often. Although the tile was off, the underlying thermal blanket was intact and no threat to landing was present.

The day's observation programme included studies of several volcanoes including Mount Pinatubo in the Philippines, Cotopaxi in Ecuador, Teide in the Canary Islands and Kiliuchevskoi in Kamchatka, Russia. Observations were also made of sites in California, Wyoming, Columbia, Nevada, Mexico, Argentina and the Galapagos Islands. MAPS observations were made of the fires in British Columbia.

One of the small thruster rockets which help to control the pointing of the Shuttle was turned off due to a temperature sensor problem. That caused all vernier thrusters to be turned off and required using the larger steering thrusters. Mission controllers decided to allow Endeavour's pointing to vary over a wider range in order to save thruster jet propellant while a software patch was being developed to bypass the failed temperature sensor.

Flight Day Seven

Mission Control sent up the software patch that would allow the failed temperature sensor on one of the vernier jets to be bypassed and the on-board computers to track the thruster temperature via a second sensor near the failed one. SRL observations had continued at a reduced pace while the software patch was being developed and tested in ground simulators. Those observations missed during the software patch development had been performed at least once before during the mission and were scheduled for further times in the missions as well, so the impact of the reduced observations was minimal.

During the day, Mission Control determined that Endeavour had sufficient consumables to provide electric power safely for a one-day mission

extension and the landing was reset for 11 October.

The day's programme of Earth observations included studies of small controlled oil and algae spills in the North Sea to determine how well space-borne radar could track such occurrences.

Flight Day Eight

During the morning, Endeavour's orbit was changed slightly and the altitude lowered to about 111 nautical miles to support interferometry studies in which observations are made from slightly different positions to provide topographic information of unprecedented clarity due to the three-dimensional nature of the collected data. The SAR instrument recorded long swaths of interferometric data from North America, Central Brazil and the Kamchatka peninsula of Russia.

Flight Day Nine

The emphasis on three-dimensional studies continued with images of glaciers, volcanoes and other sites that could eventually provide insights into movements of the Earth's surface that are as small as a fraction of an inch.

Such close monitoring may allow detection of pre-eruptive changes in volcanoes and movements in fault lines that precede earthquakes. Other future applications include tracking of global warming and cooling by monitoring the movement of glaciers and tracking floods and mudslides.

During the day Mission specialist Dan Bursch took a break from his work to provide a television tour of the crew's orbital home office as he gave Earth viewers an explanation of the Shuttle's displays, controls, computers and cameras, as well as the living accommodations.

Late in the day, small thruster firings aligned the orbiter's trajectory to



Daniel W. Bursch (right) points out one of the mission's major observation points on the map in a discussion with Thomas D. Jones, payload commander. NASA

within 65 feet of that planned when Endeavour's flight path was lowered on the previous day. This would provide for precise repetitive observations by the radar instruments.

Flight Day Ten

Overnight, Mission Specialists Jeff Wisoff and Steve Smith replaced one of three payload recorders which had malfunctioned during the preceding day's operations. The replacement procedure, for which the two astronauts had trained prior to the missions, was completed in about an hour and a half during which time only two recorders were functioning, but they provided sufficient recording capability to retain the radar data provided by the instruments.

Astronauts Bursch and Smith took time out from their environmental studies to take part in a radio interview which included phone-in questions from California school children.

Flight Day Eleven

Later in the day the crew prepared the payloads for the landing which was set for about 11:30 am at the Kennedy Space Center. In addition to the radar and MAPS instruments, the crew deactivated the GAS and middeck experiments.

Endeavour's systems were put through their end-of-mission checkouts during the day. The flight control system was tested and communications links with the ground were thoroughly checked out.

Flight Day Twelve

The weather at Kennedy Space Center was not within limits for a Shuttle landing on 11 October and accordingly, Mission Control made the decision to divert Endeavour to California's Edwards Air Force Base and to return Endeavour to Florida by the 747 Shuttle Carrier Aircraft.

The deorbit burn and reentry were normal and after completing 183 orbits of the Earth and travelling over 4,703,216 miles Endeavour returned to land on Edwards Air Force Base runway 22. The main landing gear touched down at 1:02:09 pm (KSC time) at 11 days 5 hours 46 minutes and 9 seconds Mission Elapsed Time. Nose gear touchdown came 12 seconds later and wheel stop was at 1:03:08 with Mission Elapsed Time of 11 days 5 hours 47 minutes and 8 seconds.

After landing the crew returned to Houston and Endeavour was prepared for the cross country ferry trip atop the 747 to KSC departing Edwards Air Force Base on 19 October and arriving back at KSC the following day.

Endeavour's next mission is STS-67 which will carry the ASTRO-2 astronomical instruments. Launch is planned for 2 March 1995. ■

About the Crew

Michael A. Baker, 40, Capt., USN was Mission Commander. Selected as an astronaut in 1985, he was making his third Shuttle flight having previously flown as Pilot on Atlantis' STS-43 mission in August 1991 which deployed the fifth NASA Tracking and Data Relay Satellite and also as Pilot on Columbia's STS-52 which deployed the Italian LAGEOS satellite and operated the United States Microgravity Payload instruments. He had logged more than 459 hours in space prior to STS-68.

Pilot was **Terrence W. Wilcutt**, 44, Maj., USMC. He was selected as an astronaut in 1990 and STS-68 was his first Shuttle mission.

Steven L. Smith, 35, was Mission Specialist and also making his first space flight. He joined NASA in 1989 and worked in the Johnson Space Center Payload Operations Branch prior to his selection as an astronaut in 1992.

Daniel W. Bursch, 37, Cdr., USN, was Mission Specialist-Two. He was selected as an astronaut in 1990, having previously flown as Mission Specialist on Discovery's STS-51 mission to deploy the ACTS technology satellite in September 1993 logging over 236 hours of space flight.

Mission Specialist-Three was **Peter J.K. Wisoff**, 36, PhD. He was selected as an astronaut in 1990, having previously flown as Mission Specialist on Endeavour's STS-57 mission in June 1993 logging over 239 hours of space flight.

Mission Specialist-Four was **Thomas D. Jones**, 39, PhD who was selected as an astronaut in 1990. Jones was making his second space flight having flown as Mission Specialist on STS-59 in April 1994 logging over 269 hours in space. Jones was the only crew member from that first Shuttle Radar Laboratory mission to fly on the second SRL mission.

Three Ultraviolet 'Eyes'

Spectroscopy • Astrophotography • Photopolarimetry

The eighth flight of the Space Shuttle Endeavour, scheduled to begin on 2 March 1995, will re-fly what has been described on numerous occasions as 'a proven scientific performer'. The payload in question is the ASTRO ultraviolet astrophysics laboratory, which undertook a spectacular maiden flight in December 1990 (*Spaceflight*, February 1991, p.46). Despite problems with the laboratory's pointing system, an alternate flight plan was devised and the resultant success of ASTRO-1 led directly to a decision in May 1991 to re-fly the system (*Spaceflight*, July 1991, p.224).

The original ASTRO-2 mission was expected to last for nine or ten days, making it almost identical to its predecessor, but the advent of the Extended Duration Orbiter (EDO) capability allowed programme managers to propose a longer flight of up to two weeks. The only major difference between ASTRO-2 and ASTRO-1 is the omission of the Broad-Band X-Ray Telescope (BBXRT) instrument, which was added to the 1990 flight to make observations of Supernova 1987A in the Large Magellanic Cloud, but which is no longer required.

ASTRO-2 Payload

Three ultraviolet telescopes together with their associated support equipment are mounted on two British Aerospace-built Spacelab pallets in the open payload bay. When the first flight of ASTRO got underway in 1990, it became the first Shuttle science mission to be completely dedicated to a single discipline (astrophysics) and it accordingly benefited from a higher than normal return of data.

The ASTRO-2 instruments are known as the Hopkins Ultraviolet Telescope (HUT), the Ultraviolet Imaging Telescope (UIT) and the Wisconsin Ultraviolet Photopolarimetry Experiment (WUPPE). These are all mounted on a common support structure called a 'cruciform' attached to the Instrument Pointing Systems (IPS), which is capable of precisely directing all three telescopes towards their individual targets or aiming them towards specific areas to analyse single objects in unison.

Although the IPS is affixed to the Spacelab pallets, it isolates the telescopes from all Shuttle disturbances caused by adverse movement or thruster firings. However, the UIT and WUPPE instruments require a finer degree of stability than the IPS can provide and mission managers developed an image motion-compensation system consisting of a star tracker equipped with a Charge Coupled Device (CCD) and a gyro stabiliser.

The entire ASTRO assembly is supported by the two U-shaped Spacelab pallets, which act as a base in the payload bay. Each pallet measures approximately 3 m in overall length by 4 m in diameter, and provides mechanical, thermal, avionic and power services to the payload. For ASTRO-2, one pallet will be used to hold the tele-

scope/IPS stack, while the other will contain a payload clamp assembly to hold the system in a horizontal position during the ascent and entry phases of the mission.

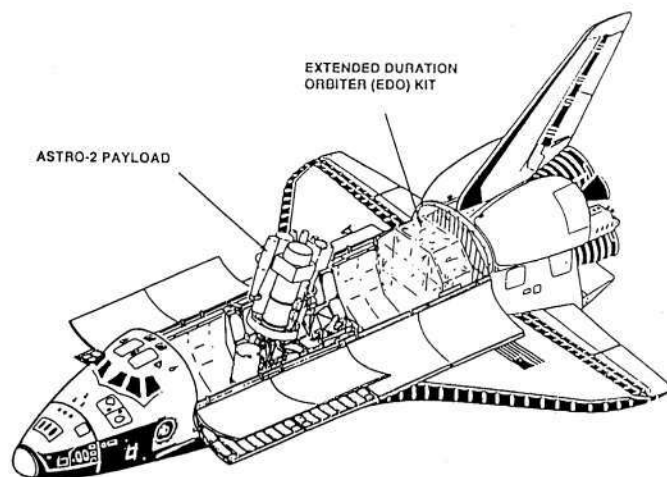
HUT: Spectroscopy of Faint Objects

The HUT instrument was, as its name implies, designed and built by the Johns Hopkins University of Baltimore, Maryland. It performs spectroscopic observations of faint objects to obtain their chemical composition and surface temperature.

The telescope optics consist of a 90 cm-diameter f/2 mirror, which focuses incoming light from a celestial source on to a spectrograph. Both the telescope and the spectrograph are capable of observing the little-explored 900-1200 Å region and also shorter ultraviolet wavelengths. The development of the HUT mirror marked a triumph for ultraviolet astronomy with the use of iridium as a coating, which is a good reflector of ultraviolet radiation.

HUT measures 3.7 m in length by 1.1 m in diameter and weighs a total of 789 kg. Interestingly, one of the Assistant Project Scientists for the instrument is Sam Durrance, who is assigned as a crew member on ASTRO-2. During its previous flight, HUT performed flawlessly, gathering 40 hours of data during 115 observations of 83 different targets. The instrument's resolution exceeded 80 per cent of pre-mission expectations, achieving the first far and extreme ultraviolet spectral observations.

Of specific interest to HUT investi-



ASTRO-2 mission configuration.

NASA

BY BEN EVANS

West Midlands, UK

gators are quasars, and the telescope will be used to observe these for short periods of time and so achieve quality spectra. Earlier observations using spacecraft such as the International Ultraviolet Explorer (IUE) took long exposures with poor results. Scientists have also speculated that quasars and the hot cores of active galaxies could be breeding-grounds for black holes, and the ultraviolet spectra returned from HUT's observations deep into such objects are expected to reveal evidence regarding their presence.

Studies will also be made of numerous stars, including binary systems, within our own galaxy. Binaries are two stars that revolve around a common centre of mass under the influence of their mutual gravitational attraction. The possibility that the larger member of the pair may transfer some of its material to its smaller companion is similar to processes taking place on a grander scale within a quasar or black hole system.

HUT will also examine the outer planets of the Solar System, placing emphasis on the ionised material which flows between Jupiter and its moon Io, as well as observations to acquire evidence for auroral activity in the atmospheres of all four gas giants.

UIT: Ultraviolet Astrophotography

When the UIT instrument first flew aboard ASTRO-1, it offered scientists their first chance of long-duration ultraviolet photography of astronomical targets. Hitherto, only a few minutes of ultraviolet imaging could be performed by balloons, sounding rockets, high-altitude aircraft and satellites. Nevertheless, the brief observing sessions revealed much about spiral galaxies, globular clusters and white

dwarfs. The ASTRO-1 mission proved highly successful for UIT, with the instrument taking over 900 images of 68 individual targets, including the first ever ultraviolet picture of the globular cluster Omega Centauri, which lies some 17,000 light years distant.

UIT was developed by NASA's Goddard Space Flight Center of Greenbelt, Maryland and is a powerful combination of telescope, image-intensifier and camera. The instrument uses extremely sensitive IlaO astronomical film, and contains 11 filters to isolate specific areas of the electromagnetic spectrum and thereby show small differences in energy levels.

The telescope is equipped with a 38 cm-diameter f/9 mirror, and its field of view is sufficiently wide to encompass entire galaxies and even galactic clusters. It has been described as a key tool for deep-space wide-angle imaging, and covers the broad middle-ultraviolet spectral range from 1200-3200 ångströms. The instrument measures 3.7 m in length, with a diameter of 81 cm, and a weight of 474 kg. Like HUT, one of the UIT investigating scientists is a member of the ASTRO-2 crew; namely, Ron Parise.

UIT most readily detects extremely hot objects, whose surface temperatures vary between 15,000 and 50,000 °K. Massive and ancient stars, including white dwarfs emit most of their radiation at ultraviolet wavelengths. It is hoped that the abundance of white dwarfs in globular clusters, where the majority of stars are of a similar age and composition, will yield clues to such fundamental problems as star formation, evolution and death.

WUPPE: In-Space Ultraviolet Photopolarimetry

The third and final ASTRO-2 instrument, WUPPE, is sponsored by the University of Wisconsin, based at Madison, and is designed to measure the polarisation of an object's emitted radiation. On the ASTRO-1 mission, WUPPE observed no fewer than 70 individual astronomical targets.

The instrument operates by splitting an incoming beam of light into two perpendicular planes of polarisation, which then pass through a spectrometer, before being focused on to two separate detectors. Photopolarimetry is difficult in the ultraviolet spectrum and, as a result, WUPPE was intended from the beginning as no more than an experimental tool. Its targets are

well-known objects for which comparative data already exist at other wavelengths. With an ultraviolet range of coverage between 1400-3200 ångströms, WUPPE is well suited for spectroscopic observations of quasars, galactic nuclei and hot stars.

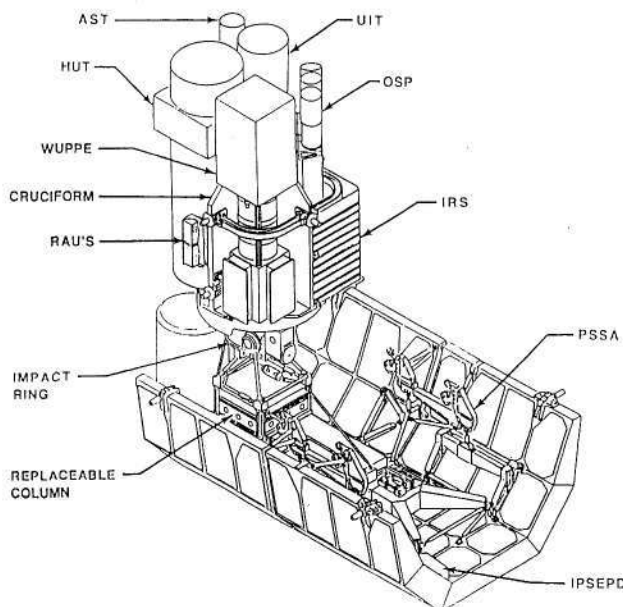
With WUPPE it is hoped to test several theories concerning the polarisation of light by very strong magnetic fields, particularly one which suggests that polarisation increases as the wavelength grows shorter. White dwarfs, too, will be considered by WUPPE, based upon theories that as their magnetic fields increase in size, so their radiation intensity stretches further into ultraviolet wavelengths.

In addition, light is polarised by tiny grains of dust existing in the void between star systems - the 'interstellar medium' - and WUPPE's studies of the resultant light scattering will assist in determining the size and shape of such particles. During ASTRO-1, the instrument made several important findings about their composition and abundance, and ultimately it is hoped that an improved insight into these gauzy 'blankets' will be of help in understanding the origins and evolution of our galaxy and others. Similarly, WUPPE will be observing the dust and gas existing within the Solar System, taking particular note of the similarities between asteroid composition and the dust in cometary tails.

WUPPE measures 3.7 m in length, 70 cm in diameter and weighs 446 kg. It contains a 50 cm-diameter f/10

ASTRO-2 payloads. Codes: AST - Astro Star Tracker; HUT - Hopkins Ultraviolet Telescope; IPSPD - Instrument Pointing System Electrical Power Distribution; IRS - Integrated Radiator System; OSP - Optical Sensor Package; PSSA - Payload Support Strut Assembly; RAU - Remote Acquisition Unit; UIT - Ultraviolet Imaging Telescope; WUPPE - Wisconsin Ultraviolet Photopolarimeter Experiment.

NASA



About the Crew

The seven-member crew for the ASTRO-2 mission, designated STS-67, is commanded by veteran astronaut **Steve Oswald**, who will be undertaking his third space flight.

By contrast, his Pilot **Bill Gregory** is a space 'rookie', as are Mission Specialists **Wendy Lawrence** and **John Grunsfeld**.

The third Mission Specialist, **Tamara Jernigan**, is also designated 'Payload Commander' with overall crew responsibility for payload science issues and already has two space flights to her credit. The two Payload Specialists are **Sam Durrance** and **Ron Parise**, who previously flew together on ASTRO-1 four years ago.

Jernigan, Durrance and Parise are trained astronomers, while Grunsfeld is a physicist, and they will become the 'science' team aboard Endeavour, conducting the bulk of the research with the ASTRO-2 instruments. Meanwhile, Oswald, Gregory and Lawrence will act as the 'orbiter' crew, responsible for the on-orbit manoeuvres and maintenance of the Shuttle throughout its long mission.

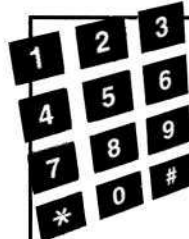
Cassegrain primary mirror, which is equipped with a spectropolarimeter instrument. One of the co-investigators for the instrument is Ken Nordsieck, who acted as the backup Payload Specialist to both Sam Durrance and Ron Parise on the original ASTRO-1 mission, prior to his resignation.

Middeck Payloads

In addition to the ASTRO-2 payload, two dustbin-sized Getaway Special (GAS) canisters will be attached to the payload bay wall. Four further secondary experiments will be accommodated in the Shuttle's middeck area. These are the Commercial Middeck Instrumentation Technology Associates Experiment (CMIX)-3, the Protein Crystal Growth-Thermal Enclosure System (PCG-TES)-3, the Protein Crystal Growth-Small Thermal Enclosure System (PCG-STES)-2 and the Middeck Active Control Experiment (MACE).

The CMIX experiment is a privately-funded payload which consists of several 'mini-labs'. The PCG-TES and PCG-STES experiments are variants of a much-flown system designed to grow high-quality protein crystals under microgravity conditions for use in the pharmaceutical industry. MACE is a technology-demonstration experiment which validates the interaction of control systems and structures in space. ■

- Launch Report



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SPACELINE

THE LATEST NEWS FROM SPACE

'Weather Satellites' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

First Prize: A. Hobson, UK

Runners up:

W.G. Maxwell, UK; J.J. Silverlight, UK.

The correct answers are: 1. Television and Infrared Observation Satellite; 2. Meteosat 3; 3. Metop.

Mir Relay

On 16 December 1994 a new relay satellite for the Mir station was launched into a transfer orbit by means of a Proton-K rocket. The satellite, called Luch, weighs 2,300 kg and joins an earlier geostationary relay satellite launched in 1989, designated Kosmos 2054. It is intended for location above the equator at 95 degrees East whereas Kosmos 2054 is currently located at 16 degrees West.

The satellite is intended to relay communications with the Mir station at times when the complex is out of range of Russian ground-based trackers. Due to the loss of their ship-based and foreign tracking stations the Russians have had to cope with relatively short periods of communication with the complex. The EuroMir-94 mission managed just 20 minutes per day of TV contact with the ground although there was more voice and telemetry relay time.

The new Luch satellite also carries a search-and-rescue transponder for the Kospas-Sarsat service and is expected to halve the transmission time for these beacon relay signals. Transponders for the service have previously been flown on the NOAA and Kosmos (Nadezhda) satellites of the USA and Russia.

NEVILLE KIDGER, FBIS

Shuttle Launch Window

Captain McCulley who was present at the premiere of 'Destiny in Space' as Guest of Honour (see p.38), commented there on the forthcoming Shuttle-Mir missions. As the current Deputy Launch Site Director for Lockheed Space Operations at the Kennedy Space Center, Captain McCulley is uniquely able to describe several of the options available for the attainment of launches of the Shuttle orbiters during the five-minute launch window to which they will be constrained for visits to the Mir space station.

Neville Kidger writes:

The question arose when I asked him about the four minute delay to the launch of the STS-66 ATLAS-3 mission on 3 November. That delay ("wasted time", in the opinion of Captain McCulley) was caused by high winds at one of the TAL sites across the Atlantic Ocean from the KSC launch site.

The ATLAS-3 mission had a long



Mike McCulley at the time of his STS-34 mission in October 1989. NASA

launch window but missions to Mir could be scrubbed several times with even 4-5 minute delays. Captain McCulley said that NASA is looking at several options to ensure that launches to Mir occur on time. One of these was restructuring the countdown to place the built-in holds at different times.

Titan IV Launch for Defense Department

On 22 December 1994 a Titan IV rocket launched a missile-warning satellite, built by TRW Inc, which was to join many others already in orbit. Defense Support Program (DSP) satellites have been the backbone of the US missile-warning system since 1970 and employ 6,000 infrared sensors to detect the intense head radiated by missile plumes or nuclear explosions.

This was the fourth launch this year of a Titan IV from Cape Canaveral. The first three used the Centaur upper stage but for this launch the Titan IV used an Inertial Upper Stage (IUS). The first launch this year was on 7 February carrying the Defense Department's first Milstar satellite into geosynchronous orbit (*Spaceflight*, May 1994, p.162). The second launch was 3 May and the third was on 27 August, both carrying classified Department of Defense payloads.

Israel Plans Launches with Russia

Following the signing in September 1994 of a Russian-Israeli memorandum of cooperation in space exploration, Israel's small "university" spacecraft, TECHSAT (*Spaceflight*, October 1993, p.345) is to be put into orbit as a sub-satellite on one of Russia's civilian satellites.

Israel is also examining the possibility of launching its communications satellite, AMOS-2, with a Russian booster rocket, Zenit-2, from the Baikonur Cosmodrome.

Israel won the status of a space power by successfully launching two experimental Ofeq (Horizon) satellites with its own boosters from a range in the Negev desert in 1988 and 1990. The third experimental Ofeq satellite packed with instruments for reconnaissance purposes is currently due for launch.

Russia's Space Programme

Mir Module Launch Dates

Boris Ostroumov, Deputy Director-General of the Russian Space Agency, reporting recently on the Russian space programme in 1994, said that it was financed to only 25 per cent of the planned figure.

The main programme of the Russian Space Agency in 1995 will be implementation of the Mir-Shuttle project.

The shuttle to be launched with Russian cosmonaut Vladimir Titov aboard must come within 50 m of the Mir orbital complex to check out systems for the next docking rendezvous scheduled for June 1995. To keep the Mir orbital complex operational it is planned to launch six Progress cargo ships in 1995.

In 1995 it is planned to launch three Soyuz spacecraft with cosmonauts aboard in March, July and December.

The Mir complex will be reinforced by the Spektr and Priroda modules, which are to be launched respectively on 10 May and 11 June.

RIA-NOVOSTI

Ariane Flights to Resume

Following comprehensive corrective action, Ariane flights are expected to resume in the second half of February 1995.

The report issued by the Inquiry Board into the loss of Flight 70 states:

Inadequate thrust was produced due to lower than normal pressure in the gas generator which drives the engine's turbopump. This lack of pressure was the result of an insufficient supply of oxygen to the gas generator which was probably caused by an inhibition of the flow of oxygen to the gas generator. The board also examined the possibility of a leak in the oxygen feeding circuit.

Arianespace, CNES and Ariane programme manufacturers, in liaison with ESA, have decided on an integrated series of 21 corrective measures.

Space Station

On 27 December 1994, a General Accounting Office report said that NASA's budget is so stretched by the cost of the proposed space station that the agency does not have the money to build a community of researchers needed to conduct the science.

The GAO, which is the investigative arm of Congress, said that in fiscal 1992, NASA had only about a third of the researchers needed for the space station's goals, but the agency is not able to increase its research budget.

A NASA spokesman said that science is the No. 1 priority on the space station and that this and any issues raised by the GAO report that have not already been addressed by NASA will be addressed at a later date.

The International Space Station is a plan to build a permanently staffed laboratory orbiting the Earth for long-term studies of the effects of weightlessness on materials and on various forms of life, including humans. The station is a joint project of NASA, Japan, the European Space Agency, Canada and Russia. It would be launched in pieces over several years and assembled in orbit by NASA, using the US space shuttle and some Russian rockets.

NASA Chief Resigns

On 12 December 1994, Kennedy Space Center Director Robert Crippen, a key backer of NASA's space shuttle programme, unexpectedly announced that he will retire to pursue interests in private business. Before he was appointed in January 1992, he headed the shuttle programme at NASA headquarters in Washington.

Jay Honeycutt, chief of shuttle operations at the Kennedy Space Center succeeds Robert Crippen when he steps down on 21 January.

Apollo Astronaut Dies

Colonel Stuart Allen Roosa, 61, USAF retired, one of six Apollo astronauts to fly solo around the Moon, died on 12 December 1994 due to complications from pancreatitis.

Roosa served as the Command Module Pilot for the Apollo 14 mission from 31 January to 9 February 1971. His fellow crew members were Alan Shepard and Edgar Mitchell. Throughout the 33-hour stay on the surface of the Moon by Shepard and Mitchell, Roosa remained in lunar orbit aboard the command module "Kitty Hawk", to conduct a variety of assigned photographic and visual observations.

Roosa was one of 19 people selected as part of the astronaut class of 1966 and served as a member of the astronaut support crew for the Apollo 9 mission. Following Apollo 14, he served as backup command pilot for Apollo 16 and Apollo 17. He was assigned to the Space Shuttle programme until his retirement as a Colonel from the Air Force in 1976.

Phaseout of Historic Mission Control

A new \$250 million Mission Control Center, housed in a new wing a few hundred metres from the existing control centre at the Johnson Space Center, is scheduled to handle its first shuttle flight in July.

The existing Mission Control is a national historic site, known for three decades to hundreds of millions of television viewers as the nerve centre of the US manned space programme. Starting with Gemini VII in December 1965, Mission Control guided the Apollo moon missions, the Skylab manned orbiting space station and space shuttle programme.

The old Mission Control will handle the ascent and re-entry of the July mission before being phased out sometime in 1996. Once a technological wonder, mission Control is now supported by obsolescent mainframe

computer equipment. During space shuttle flights a staff of about 80 people, or 240 around the clock, is needed to operate the equipment, much of which has long since disappeared from commercial use.

NASA said the new Mission Control will eliminate the NASA-unique equipment and massive hardware orientation of the current Mission Control, replacing it with a modular, software-oriented design that uses standard, commercially available equipment, sharply cutting maintenance costs and requiring about 180 fewer positions during flights.

Intelsat 703 Service

On 2 December 1994, the Intelsat 703 satellite began commercial service in the Pacific Ocean Region. It is located at 177°E and is replacing the Intelsat 511 spacecraft, which will be relocated to 180°E. Intelsat 703 will provide international telephone, broadcasting, private network (business) and domestic/regional communications services to meet the growing requirements of Asia-Pacific customers including trans-Pacific services with North America.

UK's Koreasat Role

Matra Marconi Space has assembled and shipped the transponder for the first Koreasat satellite scheduled for launch in 1995. The transponder was built at Portsmouth, UK from where it was shipped to Princeton, USA for integration by Martin Marietta Astro Space on their 3000 Series spacecraft platform. The DBS (Direct Broadcasting by Satellite) transponder has three channels and will provide the Korean population with entertainment services.

The Koreasat contract has brought together an international partnership involving Martin Marietta Astro Space (USA), Korean Air and Goldstar (Korea) and Matra Marconi Space which was selected against intense international competition to take prime responsibility for the design, development, manufacturing and testing of the communications transponders. Never before has the UK had a major role to play in producing a satellite for a Far Eastern customer.

Eutelsat's New Members

On 23 December 1994, Eutelsat, the international satellite operator, said that Andorra and the Belarus Republic have become full members of the organisation bringing its total membership to 44, and that it had approved a preliminary application from Kazakhstan. Eutelsat operates pan-European satellite networks on behalf of private and public telecommunications bodies.

Intelsat 502 Satellite Still in Service

On 6 December 1994, the first-launched member of the Intelsat V family of spacecraft marked 14 years in orbit, making it the oldest Intelsat satellite still in service. The spacecraft's design operational life of seven years has been extended by scaling back stationkeeping operations to simple East-West manoeuvres, resulting in dramatic on-board fuel savings.

Swedish Shuttle Payload

Sweden's third Get Away Special was a part of the payload on the US Space Shuttle STS-68 Endeavour (see pp.60-63).

Developed by the Swedish Space Corporation and funded by the Swedish National Space Board, the payload performed a material science experiment in microgravity. During flight a semiconductor sample was processed in a multi-zone furnace, the aim of the experiment being to study the breakdown of a planar solid/liquid interface during crystal growth from a germanium melt.

India to Lease to Intelsat

A long term agreement for India to lease transponders to Intelsat on its spacecraft INSAT-2E, to be launched in the last quarter of 1997, is due to be formalised by the end of January 1995 under which Intelsat will pay India's Department of Space \$100 million over 10 years for the use of the transponders.

INSAT-2E is one of the many second generation INSAT-2 spacecraft designed by India employing advanced technology comparable to the best in the Asia-Pacific region. A special capability will be built into the satellite for use by Intelsat in addition to the INSAT system requirement. Already INSAT is the largest domestic satellite system and will be adding to its capacity with the launch of its modified versions INSAT-2C and INSAT-2D in 1995 and 1996.

Ukrainian Cosmonaut for Shuttle

On 22 November 1994, an agreement to develop space cooperation between Ukraine and the USA was signed during a visit by the Ukrainian President to Washington. Ukraine has a highly developed space technology inherited from Soviet times and produces some of the world's most effective rocket launchers - the Zenit and the Tsyklon. The Ukrainian President Leonid Kuchma was director for 10 years of the Yuzhmash plant in the city of the Dnipropetrovsk which produced both rocket launchers for the Soviet space programme and some of the Kremlin's most sophisticated nuclear missiles. Since being elected President in July 1994, he has stressed space technology as a key field in which Ukraine can be competitive in world markets. Contacts with one US firm have already produced a preliminary agreement for Ukraine to launch 24 satellites. Ukraine is to work out a programme before the end of March for a Shuttle flight by a Ukrainian cosmonaut.

Shuttle Replacement Design Begins

McDonnell Douglas and Boeing are to compete jointly for the first phase of NASA's upcoming effort to design and develop an advanced technology demonstration vehicle called the X-33, a project to pave the way for a successor to the space shuttle which is based on 1970s technology.

Space Welding Tool

On November 1994, NASA signed a contract with the Paton Welding Institute in Kiev, Ukraine to develop a plan for flying a space welding tool aboard the Space Shuttle in October 1997. The \$36,000 contract is for the definition phase of the project. Specialists from the Institute will work with NASA engineers to design a flight experiment and conduct the required safety reviews.

The Ukrainian Universal Hand Tool (UHT) is an electron beam welding device developed at the Institute. In 1984 and 1988, Salyut 7 cosmonauts performed the first electron beam welding in space experiments during EVAs using the UHT. The definition phase contract ends in June 1995. A separate contract will be awarded for the flight phase of the project.

Avica Heads for Saturn

Avica, a Meggitt Aerospace company, has won a \$4 million-plus contract from Martin Marietta to supply the titanium flexible hoses for the hydrazine-powered attitude control system on the NASA spacecraft Cassini, which will be launched on a 12 year mission to explore the planet Saturn, its rings and moons in 1997.

Avica, with UK facilities at Hemel Hempstead, Herts and in the USA, supplies ducting for both Ariane 4 and Ariane 5 engines and inconel liquid hydrogen lines for the McDonnell Douglas DC-X single-stage-to-orbit prototype vehicle.

Baikonur Deal

On 10 December 1994, the Russian and Kazakh Prime Ministers, V. Chernomyrdin and Akezhan Kazhegelden signed an agreement in which Russia will pay \$115 million per year to Kazakhstan to lease parts of the Baikonur Cosmodrome. The lease covers the territory of Baikonur and the town of Lenininsk and its infrastructure for the next 20 years.

Chile-China Agreement

On 19 October Chile signed an agreement with China to track Long March-3 rockets as they launch communications satellites into space 630 km above the Chilean coast. Chile's Space Studies Centre which is reputed to be the largest tracking station in Latin America, will track 11 rockets bearing 22 satellites due to be launched between 1996 and 2002.

India-Ukraine Accord

In November 1994, India and Ukraine signed an agreement for cooperation in the areas of remote sensing, communication, material processing in space and mutual use of ground facilities. The agreement provides for joint research missions by sending scientific payloads in each other's spacecraft.

Finland Joins ESA

On 1 January 1995, Finland became a full ESA Member State bringing total membership to 14. Finland, which acquired the status of an associate Member State on 1 January 1987, has since been participating in ESA's Earth Observation and Telecommunications programmes as well as in its Science programmes.

Two Important Reference Volumes

The RAE Table of Earth Satellites, 1957-1989

1056 pages, published in 1990. Original price £95.

The Society has acquired a stock of the RAE Table of Earth Satellites, a substantial volume originally published at £95 which it is now making available to members at the incredible price of £7.50 (US\$15), plus £4.50 postage and packing in the UK. £9 (US\$16) abroad.

The RAE specialised in the analysis of satellite orbits to determine the Earth's upper atmosphere density and winds, as well as its gravitational field. In order to choose suitable satellites, a listing was necessary, thus leading, over the years, to the present volume containing data on more than 17,000 satellites, including fragments, in 893 pages of tabulation. Extensive revisions have been made to this, the fourth edition, to include not only all new launchings to extend the period covered to 1989 but also to incorporate over 1,000 revisions to the earlier data.

DRA Table of Space Vehicles, 1958-1991

The Society has also acquired the remaining stock of the DRA Table of Earth Satellites, originally published for £30 and now available from the Society at £5 (US\$10) post free.

This is a companion volume to the Earth Satellite Table runs to 113 pp and lists all 124 space vehicles to escape from the Earth over the 1958-1991 period. Data features the name and international designation of each spacecraft and its associated rocket(s), launch date, mass, shape and size and details of orbit or trajectory. Where appropriate the time and place of impact or landing on the Moon or planet are given.

ORDER FORM

Please send me the following: Please Tick

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☐ DRA Table of Space Vehicles, 1958-1991

I enclose a remittance payable to the British Interplanetary Society totalling £..... (US\$.....)

Name:

Address:

Send to The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1BZ, England.

Pluto Mission

Sir, In November 1994 while attending a meeting of the Division for Planetary Sciences of the American Astronomical Society, NASA Administrator Daniel Goldin announced that he had decided to abandon plans for a Pluto Fast Fly-by (PFF) mission as the cost of \$580 million was far too much.

For rather more than a decade there has been growing appreciation among astronomers of the key place and scientific importance of Pluto and its satellite Charon for unravelling the evolution of the outer Solar System and for understanding the early stages of planetary formation within the primordial solar nebula. The Voyager 2 encounter with Triton, Neptune's largest satellite, revealed that it and Pluto were not dissimilar in mass and appeared to be more chemically and physically alike than had been anticipated.

The discovery, in a period of less than fourteen months between August 1992 and September 1993, of two trans-Plutonian dwarf planetary bodies 1992QB and 1993FW at heliocentric distances of ~44.4 au and ~47 au, and of four other similar small bodies 1993RO, 1993RP, 1993SB and 1993SC at distances from the Sun of 32 to 35 au which appear to be the first examples of Kuiper Belt objects has also focused attention on the fact that Pluto, Charon and Triton may be the largest surviving representatives of a vast number of near primordial planetesimal-like objects which populated the outer regions.

The importance of securing a mission to reach Pluto by, or preferably before, 2010 is dictated by Solar System geometry. If we are to be able to collect the data of the greatest significance for understanding the nature and composition of the primordial composition of the solar nebula and of the formation and evolution of proto-planetary bodies we need to reach Pluto a decade or more before the atmosphere ceases to be gaseous and is recondensed and frozen upon the planet's surface, a process estimated to be substantially completed by ~2025 AD. Only during the active stage can data be obtained regarding the interaction between the Plutonian envelope and the solar wind plasma and the climatic materials transport cycles that affect the planetary surface. Pluto reached perihelion, a heliocentric distance of <30 au, in 1989 and is now moving away from the Sun towards its aphelion at a distance of 50 au. If the present opportunity to study of the planet is lost it will not be possible to study Pluto in the active state until it approaches its next perihelion circa 2237 AD. This is a period of time longer than that for which the USA has existed as an independent nation.

The paradox of the fate of the PFF mission is that, on taking up his post as NASA Administrator, Dan Goldin himself announced the PFF mission concept citing it as an outstanding example of his better, cheaper, faster philosophy for future NASA missions. The PFF mission calls for two small light-weight space-

craft to fly to Pluto on a fast direct trajectory with an elapsed time from launch to Pluto encounter of no more than seven years. This PFF mission flight time is rather less than half that for mission profiles that require a Jupiter gravity assist, also the choice of launch windows is less restricted. (A PFF mission launch in 1999 would reach Pluto in 2006 some nine years sooner than a Jupiter swing-by mission through the November 2001 launch window which would reach the planet in 2015/16.)

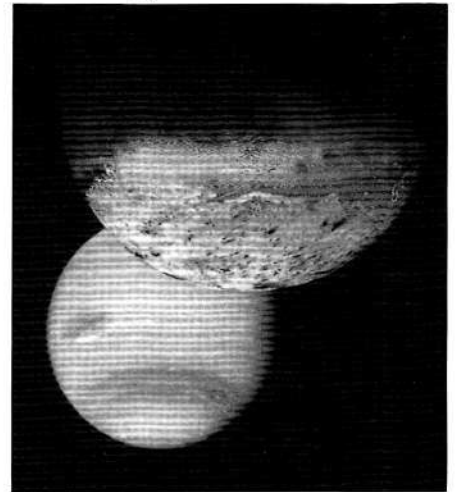
Only months after announcing the PFF mission as a showpiece example of a new NASA philosophy Goldin began to express concerns regarding the likely cost of the mission and a lower target cost ceiling was set. A little over a year ago the JPL team were told by Goldin that if the total PFF mission cost could be reduced to, or below, \$750 million it would have his backing. They were also encouraged to seek the participation and collaboration of the Russians. The success of the JPL team in tackling the task was considerable. The revised mission would ride on the Russian Proton rocket and additionally would carry a small Russian probe to be dropped into Pluto's atmosphere. The cost of the PFF mission was reduced by some \$170 million below the target set by Goldin, to \$580 million for the two spacecraft mission.

Why then has the PFF mission been effectively killed? Goldin himself now seems to favour the supposedly cheaper 'Discovery' missions and there is also a wish for a NASA participation in the ESA Rosetta project. None of these missions is time sensitive as is the case of Pluto. This time sensitivity should be grounds for prioritization. One or more of the non-time sensitive planetary missions could be postponed. Nothing need be irretrievably lost and none of the delays would amount to anything like 240 years.

The problem seems to resolve itself according to the strength of scientific lobbies and pressure groups. The number of scientists engaged in the study of

'KSC' on Radar: During the weekend following STS-68's launch (see p.60), volunteers gathered at KSC headquarters to assemble 29 corner reflectors for use in calibrating its Space Radar Laboratory as it bounced signals towards KSC. The reflectors were arranged to spell 'KSC' over a distance of 650 m outside KSC headquarters. The trihedral reflectors are tilted to return the maximum signal to Endeavour. Post-flight processing of the received signals is necessary and will take two to three months.

PETE GUALTIERI, WEST KENTUCKY NEWS



Neptune and Titan imaged by voyager 2 on 25 August 1989. NASA

the outer solar system is relatively small and for this reason lacks the strength of larger pressure groups. The considerable interest and concern that a mission should be sent to Pluto before it goes into deep-freeze has been shown by a large group of senior British scientists (through the BIS) earlier in the year and by the Planetary Society in the USA whose independent mission cost and profile evaluation appears to have influenced the decision for collaboration with the Russians and use of the Proton rocket.

Must all possibility of reaching Pluto before 2010 now be abandoned or is there some other way of achieving what many of us believe to be a scientific goal of the greatest importance in understanding the formation and evolution of the Solar System and perhaps the origin of life itself? I would hope not - what is needed is a financial resource of \$120 million per year for five years. Are there any outward looking philanthropists willing to fund the exploration of Pluto and Charon and the neglected frontier of the Solar System?

RICHARD L.S. TAYLOR
London SW16

Apollo Look-Back

Sir, It was with interest that I read E.T. Pugh's article *Other Factors Behind 'Go to the Moon'* in the October issue of *Spaceflight*. However, several of his statements deserve correction and clarification.

He states that Lyndon Johnson "actively opposed Kennedy on his plans to disband the NASC (National Aeronautics and Space Council) and was prepared to use his power as Chairman of the threatened Council to do so". This is incorrect.

The NASC was created as part of the same legislation that created NASA. It was opposed by Eisenhower and substantially watered down in order to gain his approval. The legislation stated that the President was to chair the Council. Eisenhower allowed the Council to languish toward the end of his term and recommended that it be disbanded. When Kennedy won the election, the future of the NASC was in doubt. Although it is popularly thought that Johnson convinced Kennedy that he, as Vice President, should be chairman, the credit for the idea actually belongs to Richard E. Neustadt. Neustadt served as a consultant to the Kennedy transition team, and later became a prominent expert on the Presidency. In a 20 December 1960 memorandum to Kennedy, Neustadt stated, "An opportunity now exists to revitalize the National Aeronautics and Space Council under the Chairmanship of the Vice President". Kennedy accepted Neustadt's recommendation, but many other details of the organisation of the NASC remained to be worked out. Neustadt, Nicholas de Katzenbach (Assistant Attorney General), and Edward C. Welsh (nominated to be the first Executive Secretary of the NASC) all contributed to the structure of the Council. The Neustadt memo was provided by Neustadt to historian Giles Alston, who forwarded it to me when I was writing a history of the NASC. It is not contained in the National Archives collection of NASC documents, although other important letters and memos addressing this issue are.

Furthermore, Johnson's ability to use his position to oppose Kennedy was quite limited. Vice Presidents have extremely limited powers. One of the reasons Kennedy had named Johnson as his running mate was to remove him from the powerful position of Senate Majority Leader. Although Johnson was very important in shaping American space policy, he did this in support of Kennedy, never in opposition to him. If he had opposed the President, Kennedy would have ignored him. Although the President cannot ask the Vice President to resign, since it is not an appointed, but elected, position, the President has the option of incorporating the Vice President into his close circle of advisors, or simply sending him to attend funerals.

Pugh's comparison of Apollo to Roosevelt's Tennessee Valley Authority (not "Scheme") is also not quite accurate. TVA was part of Roosevelt's New Deal programme to recover from the Depres-

sion by pouring massive amounts of government funds into public works projects. Economic analysis shows that these programmes were unsuccessful in spurring recovery and it was only the advent of World War II that really pulled the United States out of the Great Depression.

Finally, although it is true that the groundwork for Apollo was laid several years before Kennedy made his decision, and it is also true that Johnson was a major advocate for the programme within the administration, credit still belongs to Kennedy. Neither Congress nor the bureaucracies can push forward a major programme in the United States that lacks presidential approval. Presidential support is not sufficient for success, but it is certainly necessary for it.

WAYNE A. DAY
Space Policy Institute
Washington, DC

A response has been provided by Mr E.T. Pugh as follows:

May I deal with the points raised in reverse order. To accept that the major credit should be Kennedy's just because he was President is a rather semantic point. Of course he eventually came to recognise the political importance of Apollo and gave it the public support necessary. But that is not the same as being the driving force behind it. Politically, in my opinion, that was Johnson.

The second point raised takes me to task for referring to the TVA as a 'scheme'. Surely this is a matter of timing. The 'Authority' was formed to run and manage the 'scheme'. Once it was given the go-ahead. In mentioning it I was attempting to draw attention to the similarities between them. Both the TVA and Apollo were in the years of Democratic Presidents; both involved huge sums of Government money to counter depression in specific parts of the USA; both were used to bolster political popularity; both fell foul of a war; and both had their economic benefits questioned. I stick to my original point that Kennedy saw the expediency of directing Government money into the Southern States as a means of preserving his chances of re-election in 1964.

Now to the nub of the letter. The key to unravelling Johnson's role hinges on the date of the Neustadt memorandum - 20 December 1960. Murray and Cox in their well researched book, 'Apollo, the Race for the Moon' cite this date as the day of a meeting between Kennedy and Johnson in Washington which reversed a planned policy to disband the NASC and with it NASA's only unhindered line of communication to the President. That NASC was about to go was confirmed by Theodore Sorenson, the White House aide charged by Kennedy to assist in this area with the transfer between administrations.

Johnson is widely reported not to have liked this decision. Murray and Cox, and John M. Logsdon (The Decision to go to the Moon - 1976) are clear about the Vice-President's part in affecting a change of mind, even at the expense of down grading the importance of the Chairmanship. In fact, Murray and Cox go further and say that this is further evidence of Kennedy's lack of enthusiasm for space. Would he relinquish his position on this body if he had plans to

put it at the forefront of the nation's plans over the coming decade?

If the Neustadt memo precedes the meeting mentioned, then it has to be the fastest piece of Government reaction to advice ever taken. Or was it written as a confirmation that the President had acted wisely in resolving a difference between himself and his forceful Texan partner?

Whichever it is, the fact remains that Kennedy was initially in favour of disbanding NASC. Johnson thought it was a bad idea. They met. NASC continued. If that is not opposing the President, what is? Kennedy clearly did not ignore Johnson. He could not afford to. Ultimately, if Dallas had not intervened, he would need Johnson's support to get re-elected.

Russian Potential for Air Launch to Orbit

Sir, I read with great interest [1] about a proposed air-launched version of the Zenit booster by 1998.

After studying the Zenit booster in some detail [2], it seems likely that the air-launched version (limited in mass to about 250 tons or the AN-225 payload capacity) is likely to use the RD-180 rocket engine [3] with two thrust chambers instead of the RD-170.

Launched at an initial relative velocity of around 230 m/s at a height of about 11 km, the approximate masses of the first and second stages would be 170 and 70 tons respectively. Adding 9 tons of payload plus 1 ton for the shroud would tip the scales at 250 tons. Burn times are 130 s and 250 s respectively. Values were deduced by interpolating the specifications given for the Zenit launcher in [2].

This air-launched configuration could likely be the workhorse of the Russian/CIS space programme, replacing the A-2 launcher at the turn of the century. Imagine a Soyuz or a Progress spacecraft launched from the top of an AN-225!

The MAKS system is of course a more efficient approach but with higher development costs. Both of them could live side-by-side in a future replacement of some of the older expendable boosters.

In the small launcher category, the Burlak booster has very attractive performance/cost characteristics [1]. With a development cost of only \$30 million (the cost of a single fighter aircraft!) it has twice the payload capacity of the Pegasus at almost half the price tag for a typical commercial launch.

I think Dara's funding of Burlak's feasibility study is a wise decision the Germans have made.

Perhaps other European countries like France and England should do the same, knowing of the growing interest in the small satellite sector.

M.Q. HASSAN, FBIS
The Middle East

References

1. *Aviation Week and Space Technology*, 27 June 1994, pp.72-75.
2. *International Reference Guide to Space Launch Systems*, AIAA 1991, pp.169-180 and pp.217-230.
3. *Aviation Week and Space Technology*, 2 August 1993, p.64.

Images from Satellites

Sir, The successful launch in October of the oceanographic satellite Okean-4 (officially called Okean 1-07) has once more given suitably equipped amateurs an opportunity to receive some spectacular imagery. During the mid-eighties I set up a domestic satellite receiving station and quickly found that many of the signals received could be decoded.

This new Okean is the fourth in a sequence which officially started in July 1988 with the launch of Okean-1. Before that, images of varying quality were received from Cosmos 1500, 1602, 1689 and 1766. These all transmitted APT (Automatic Picture Telemetry) on 137.40 MHz, scanning at 4 lines per second, as did Okeans 1, 2 and 3.

The new satellite has the orbital characteristics of previous satellites in this series; a period of about 98 minutes, giving a Mean Motion (number of orbits per day) of about 14.7. The satellite orbits between 631 and 666 km above the Earth - significantly less than either NOAA or Meteor (weather satellite) orbits, but similar to previous Okean craft.

The oceanographic satellites differ significantly from their weather satellite counterparts in the nature of their sporadic (non-continuous) transmissions, and by the type of transmission. Sometimes visible-light pictures occupy almost the whole frame format. Occasionally the frame is split into sections containing different types of imagery. On-board equipment includes a side-looking radar system, an optical low-resolution, multi-channel scanner, and a multi-channel microwave radiometer.

The radar image has a published resolution of about two km, and is often of high quality, but rarely lasts for more than a

few minutes. I suspect that the reason for this short duration is the power requirement of the radar system. It looks sideways from the satellite's direction of travel and is power hungry. This theory is supported by the observation that most radar images occur during the sunlit section of the orbit, while the solar panels are well illuminated.

One of the many picture formats transmitted by this series includes a sequence of numbers related to on-board operations. One of these increments each minute and is associated with the time lapsed, in minutes, since midnight in Moscow. Other numbers have been identified by researchers as relating to the operation of individual items of equipment.

In future months we may receive regular imagery, particularly if there is a significant ice build-up in the Bothnian area. Okean satellites have played a significant role in ice monitoring in the northern hemisphere.

LAWRENCE HARRIS
Plymouth, UK

Journalist Honoured

Sir, It is my great pleasure to inform you that Prof Ernst von Kluon (born 1915) - BIS member since August 1957 - has been awarded the well-respected honour prize ring of the Eduard-Rhein-Foundation for his life's work as a journalist of high renown during which time he helped to bring major results of modern science and technology to the attention of the public.

Most cordial congratulations to you, my friend!

HARRY O. RUPPE
Munich, Germany

R.H. Goddard, Composer

Sir, I have been interested in the articles on 'Space Music' that have appeared in *Spaceflight*, but there is an example I am sure very few people know about.

The music and words of 'Old Tech', a college song of the Worcester Polytechnic Institute, were written by Robert H. Goddard in 1908 when he was a graduating student.

It was published in *Two Towers: The Story of Worcester Tech 1865 - 1965* by Mildred McClary Tymeson, which was presented to me when I lectured there during the late 60s. It was a memorable occasion because Mrs Goddard was sitting in the front row.

ARTHUR C. CLARKE
Colombo, Sri Lanka

Space Poetry

Sir, Ted Edwards' 'space song' (*Spaceflight*, May 1994, p.176) reminded me of the following poem written by John A. Sentry in a short story called 'The Stoker and the Stars', published in *Astounding Science Fiction* in May 1959:

The rockets rise against the skies,
Slowly; in sunlight gleaming
With silver hue upon the blue.
And the universe waits, dreaming.
For men must go where the flame-winds blow,
The gas cloud softly plaiting;
Where stars are spun and worlds begun,
And men will find them waiting.
The song that roars where the rocket soars
Is the song of the stellar flame;
The dreams of Man and galactic span
Are equal and much the same.

ROGER W. WHITE
Lincs, UK

Spaceflight Crossword

No. 18

ACROSS

1. Stationary spacecraft on a planetary surface
2. Device used in docking operations
8. Commander of the first 1991 Shuttle crew in orbit
9. Proposer of the nebula theory of the Solar System's origin
10. Dozens
11. Parts of 1. Across that may be in contact with the planetary surface
12. Radio hobbyist
14. Shock
15. Non-metric unit of 1. Down
18. Heat and light source
21. Angle
23. Fruit-tree garden
25. Communications satellite
26. Commander of second

Shuttle to be launched

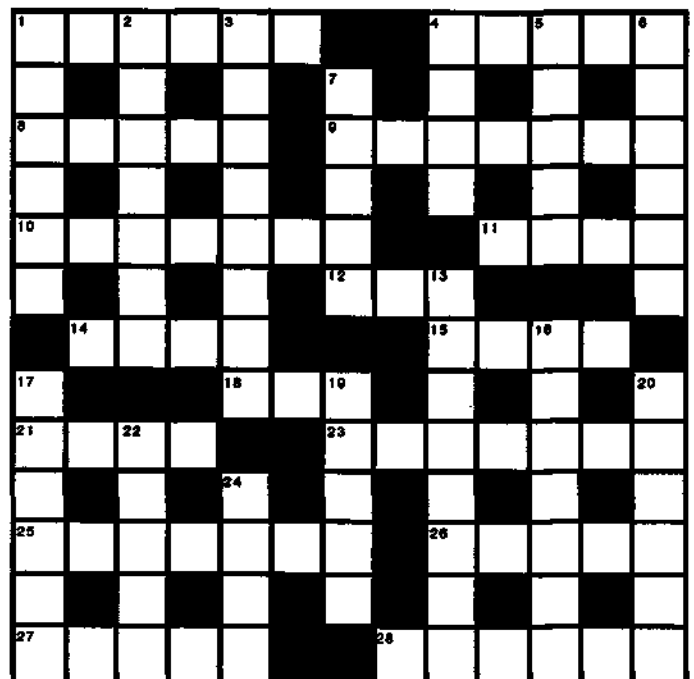
27. Come in
 28. Conceal
- ### DOWN
1. Dimension
 2. Disregard
 3. Animates
 4. Tube
 5. Hold forth
 6. Votes into office
 7. Contradiction
 13. Apollo 14 astronaut
 16. Accumulations of electricity
 17. European space launch vehicle
 19. Point of the compass
 20. Arrival
 22. Mir astrophysics module
 24. —friendly

Solution will appear in the March issue.

Solution to Crossword No.17.

ACROSS: 7. Ruling; 8. Attach; 10. Mission; 11. Prime; 12. Unit; 13. Texas; 17. Carve; 18. Fair; 22. Rings; 23. Unified; 24. Spring; 25. Adhere.

DOWN: 1. Frimout; 2. Clastic; 3. India; 4. Stopgap; 5. Faris; 6. Sheet; 9. Endeavour; 14. Cassini; 15. Galileo; 16. Bradley; 19. Grosse; 20. Infra; 21. Winds.



SATELLITE DIGEST-273

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch	Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Astra 1D	1994-070A	Nov 1.03	Kourou	Ariane 42P	2,924	Nov 13.20	0.13	1,436.04	35,712	35,859	[1]
Wind	1994-071A	Nov 1.37	ER	Delta-2	1,267	Nov 2.0	28.76	20,673.75	187	486,099	[2]
Cosmos 2293	1994-072A	Nov 2.04	Tyuratam	Tsyklon-M	3,000 ?	Nov 2.49	65.03	92.78	404	417	[3]
Atlantis	1994-073A	Nov 3.71	KSC	Shuttle	95,191	Nov 3.71	57.00	90.59	295	312	[4]
CRISTA-SPAS	1994-073B				3,263	Nov 4.56	56.97	90.57	294	310	[5]
Resurs-O1 1	1994-074A	Nov 4.24	Tyuratam	Zenit-2	1,900 ?	Nov 5.04	98.05	97.98	661	663	[6]
Progress-M 25	1994-075A	Nov 11.31	Tyuratam	Soyuz	7,250 ?	Nov 13.88	51.65	92.43	393	395	[7]
Cosmos 2294	1994-076A	Nov 20.03	Tyuratam	Proton-4	1,300 ?	Nov 30.76	64.89	669.14	18,792	19,135	[8]
Cosmos 2295	1994-076B				1,300 ?	Nov 27.04	64.82	683.58	19,152	19,503	
Cosmos 2296	1994-076C				1,300 ?	Dec 1.71	64.85	675.95	19,129	19,142	
Cosmos 2297	1994-077A	Nov 24.39	Tyuratam	Zenit-2	9,000 ?	Nov 24.88	71.00	101.97	849	854	[9]
GEO-IK 1	1994-078A	Nov 29.12	Plesetsk	Tsyklon	900 ?	Nov 29.59	73.61	116.06	1,480	1,527	[10]
Orion 1	1994-079A	Nov 29.43	ER	Atlas-2A	2,340	Dec 1.81	3.43	3,766.27	25,074	122,543	[11]
DFH-3 1	1994-080A	Nov 29.71	Xi Chang	CZ-3A	2,230	Nov 29.86	28.53	635.37	181	36,026	[12]

NOTES

- Domestic TV broadcasting communications satellite, initially located over 14-15 °E, but is to be operational over 19.2 °E.
- Wind is a spacecraft built by Martin Marietta Astro Space as part of the Global Geospace Science (GGS) mission, part of the International Solar Terrestrial Physics (ISTP) programme. Spacecraft manoeuvres will permit a double lunar swing-by orbit reaching out to 1.6 million km: after two years the satellite will enter a halo orbit about the Earth's L1 libration point relative to the Sun. The satellite had no orbital data issued via the Goddard Space Flight Center, and the orbit quoted above is taken from material released from McDonnell Douglas Aerospace after the launch.
- EORSAT (ELINT Ocean Reconnaissance Satellite).
- STS-66 mission: carried six astronauts: D.R. McMonagle (commander), C.L. Brown (pilot), E. Ochoa (payload commander and mission specialist MS-1), J.R. Tanner (MS-2), J-F Clervoy (MS-3: European Space Agency astronaut from France) and S.E. Parazynski (MS-4). With Clervoy in orbit aboard the shuttle and Merbold aboard the Mir Complex, ESA had two astronauts in orbit simultaneously for just over 18 hours. Main payload in the cargo bay was ATLAS 3 (Atmospheric Laboratory for Applications and Science) using Spacelab hardware: mass 3,759 kg. Landed at Edwards Air Force Base November 14.65.
- CRISTA-SPAS is the second in a series of flights conducted jointly with the German Space Agency (DARA), the first being ORFEUS-SPAS (1993-058C) carried on the Discovery/STS-51 mission. It carried two instruments: Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) and Middle Atmosphere High Resolution Spectrograph Investigation (MAHRST). Deployed from Atlantis Nov 4.53 and retrieved November 12.55.
- Third operational Resurs-O1 satellite to be launched. Previous flights were within the Cosmos programme: Cosmos 1689 (1985-90A) and Cosmos 1939 (1988-032A), plus programme precursor Cosmos 1484 (1983-075A). Satellite carries German SAFIR-R data-relay demonstration package. First civil satellite to be launched using Zenit-2 vehicle and the second flight to a retrograde orbit by the vehicle.
- Unmanned cargo freighter, carrying supplies to the cosmonauts aboard the Mir Complex. Docked at the rear port of Kvant 1 November 13.38 (09.04 GMT).
- Three Uragan navigation satellites in the GLONASS system.
- Large ELINT satellite. Ascending launch vehicle was seen by a pilot flying from Nagoya (Japan) to London.
- Satellite in the geodetic GEO-IK programme. Previous launches in the GEO-IK series have been within the Cosmos programme.
- Orion 1 is a communications satellite built by British Aerospace and operated by Orion Atlantic (a partnership of eight companies). Planned location is 322.5 °E. First use of such an eccentric super-synchronous transfer orbit for a geosynchronous launch.
- Dong Fang Hong-3, first flight of new-generation Chinese communications satellite.

ADDITIONS AND UPDATES

- 1994-006B ODERACS A decayed from orbit 1994 October 2.
- 1994-006C ODERACS B decayed from orbit 1994 October 4.
- 1994-010A The primary payload on the maiden flight of the CZ-3A launch vehicle has been designated "KF-1" in Chinese literature, but there is no indication of what the abbreviation expands to. Rather than being a dummy satellite, this appears to have been an instrumented payload, but further details are awaited.
- 1994-036A Soyuz-TM 19 with the three cosmonauts Malenchenko, Musabayev and Merbold undocked from the rear port of Kvant 1 November 3.44 and retreated to a distance of 190 metres. An automatic re-docking was then performed at 1994 November 3.46. The final undocking of the spacecraft from the Mir Complex with the same cosmonauts on board took place 1994 November 4.31. Landing 170 km NE of Arkalyk came 1994 November 4.47.
- 1994-053A Add a further Cosmos 2290 orbital manoeuvre: November 15.19, 64.81°, 90.28 minutes, 210 km, 367 km.
- 1994-064 The launch date for INTELSAT 703 should be October 6.27.
- 1994-069A At the end of November 1994 USSPACECOM data indicated that Elektro 1 was still drifting and on November 30.0 it was passing over 45 °E. The satellite had been expected to be deployed over 76 °E.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

1 February 1995 7 - 8.30 pm

Great Balls of Ice - The Satellites of the Outer Planets

Dr David A. Rothery
The Open University

The giant planets have considerable families of satellites, all icy except Io. Counting Pluto and Charon, there are 18 icy bodies large enough to have assumed spherical shapes (>200 km radius). Although their outer regions are icy, the processes that occur upon and within them mimic the geological processes, such as volcanism and tectonics, with which we are familiar on terrestrial planets.

8 March 1995 7 - 8.30 pm

Missions to Mercury - Future Study Possibilities for the Innermost Planet

Prof G.H.A. Cole
University of Hull

Preliminary Announcement - Mercury has been the target of only one space mission to date. It is now some twenty years since, over a period of ~28 months, the Mariner 10 spacecraft made a series of three fly-by encounters with the planet. Although only about one third of the surface was seen the innermost planet was found to possess a number of unique structural features. More surprising was the detection of a dipole magnetic field with a probable strength of 1% of that of the Earth's. The importance of Mercury in the study of the Solar System has now led to the possibilities of sending further missions to Mercury to come under consideration in NASA, ESA and elsewhere. In this lecture

Professor Cole will review current knowledge and will be discussing the scientific aims and the options available for the study of Mercury by proposed and possible future missions to the innermost planet.

5 April 1995 7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack
Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Many potentially cheaper ways have been suggested, ranging from the plausible to the fantastic. But how to tell which is which? Can we rely on the judgement of the big space agencies? Colin Jack will be discussing the proposals, and trying to pick some winners. Suggestions from the floor will be welcome!

3 May 1995 7 - 8.30 pm

The Design, Instrumentation and Function of the Cassini Mission Titan Surface Probe (Huygens Lander)

Dr John Zamecki
University of Kent

The Cassini Huygens mission to Saturn and Titan will be one of the major missions of space exploration of the next decade. The mission will be described with emphasis on ESA's contribution, the Huygens Probe, which will land on the surface of Saturn's largest moon Titan.

SYMPOSIA

26 April 1995 10 - 4.30 pm

Electronics in Space

Major advances in electronics in recent years have had an enormous impact on spacecraft design and on what can be accomplished in space within a given mass and volume. This one-day symposium will cover some of the more important developments in this field, such as the use of microprocessors, transputers and highly efficient switched-mode power supplies. It will also include the latest information concerning the effects of the space environment on advanced electronics systems.

Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

3 June 1995 10 - 4.30 pm

Soviet/CIS Astronautics

The Soviet/CIS symposium is acknowledged as one of the foremost meetings for the presentation of material on current and historical reviews of the space programmes of the Soviet Union and its successor Republics. The meeting attracts Fellows, members and other leading experts from Europe and the United States. Many of the papers are reproduced in *Spaceflight* and *JBIS Soviet Astronautics* issues.

Papers already offered for the next symposium include the current NASA-Russian Cooperation Programme, a review of the politics of the Soviet Space Programme in the 80s and important papers on one of the Soviets' unmanned programmes. Offers of papers on other topics of interest to the Society are invited.

Please send details to the Executive Secretary. *Advance Registration is necessary.*

Registration Forms are available from the Executive Secretary. Please enclose a sae.

13 September 1995 10 - 4.30 pm

Low-Cost Satellites

In response to a general concern about the escalating expense of space missions, many organisations have been attempting to reduce costs substantially, primarily by the innovative design of micro- and mini-satellites. In this context, advanced technologies and new project management techniques have had a major impact on what can be achieved with smaller masses and volumes, and thus with less costly launch vehicles. This one-day symposium will include papers on topics relevant to this theme, reviewing results achieved, applicable technologies and management options.

Advance Registration is necessary.

Registration: Forms are available from the Executive Secretary. Please enclose a sae.

Society Bye-Laws

The Society's Bye-Laws have now been amended to accord with the changes to its Memorandum and Articles of Association approved at the 49th Annual General meeting held on 17 August 1994.

Copies of the revised Bye-Laws, which incorporate these changes, may now be obtained from the Executive Secretary on request enclosing a reply paid envelope.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

JBIS



The February 1995 issue of the *Journal of the British Interplanetary Society* is now available. It features the third of our series of studies entitled "Return to the Moon" with the following papers on the theme of:

Lunar-Based Astronomy

Astronomy and Space Science from Station Moon

Highlights from the COSPAR Symposium: "Astronomy and Space Science From The Moon"

Lunar-Based Optical Telescopes: Planning the Astronomical Tools of the Twenty-First Century

Lunar Dust, Lunar Observatories, and Other Operations on the Moon

The Lunar Ultraviolet Telescope Experiment (LUTE): Enabling Technology for an Early Lunar Surface Payload

Reliability of Telescopes for the Lunar Surface

Candidate Site for a Robotic Lunar Observatory: The Central Peak of Riccioli Crater

Copies of *JBIS*, priced at \$5.00 (US\$9.00) to members, \$17.50 (US\$32.00) to non-members, post included, can be obtained from the address below. Back issues are also available.

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The BIS Video Collection

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SPACE '93 Satellite Link-Up

A fascinating, informative chat by Arthur C. Clarke, describing his work - past, present and future, as he responds to questions put by BIS members at the Society's 60th Anniversary Meeting on 17 October 1993.

The question and answer session is led by astronomer and "Sky at Night" TV personality Patrick Moore and by lunar astronaut Buzz Aldrin. A lasting and entertaining record of a unique occasion.

The video pictures are exclusively of Arthur C. Clarke, with audio presentations by other participants. **50 mins**

STS-46: Mission Highlights

This features the 12th flight of Atlantis with a crew of seven. Flight objectives included the deployment of the European Recoverable Satellite (Eureca) using the Robot Arm operated by Mission Specialist Claude Nicollier and the first, though unsuccessful, launch of a Tethered Satellite. **50 mins**

STS-54: Mission Highlights

The flight of Endeavour with a crew of five features splendid scenes of the launch of the Tracking and Data Relay Satellite (TDRS) against an Earth backdrop and experiments with Biopack. Onboard crew activities include a variety of physical exercises. The video concludes with spectacular EVA and Earth shots. **50 mins**

STS-49 Mission Highlights

The details of this flight by the Shuttle Endeavour, 7-16 May, 1992, are well covered, e.g. the preliminaries of suiting-up, the White Room, entry to orbit, removal of gantry, count-down, engines start, lift-off, and detailed operations during the flight. A principal aim was to retrieve the Intelsat VI satellite which had previously failed to reach synchronous orbit. Though more difficult than expected, it was achieved and sent on its way. A second aim was to practice basic space station assembly work by Extra-Vehicular Activity (EVA). This was also very successful. The video concludes with an interesting press interview with the crew. **1hr 50 mins**

Giotto - Encounter With Halley

This ESA video covers the history of the famous comet from its earliest sightings to ESA's Giotto mission that flew within 600 km of the icy body in 1986. **56 mins**

Ulysses, The Movie

In this ESA video, superb computer graphics describe the mission of the ESA/NASA solar polar probe launched by the Space Shuttle in October 1990. **26 mins**

A Collection of "The Movies": LA, Earth, Mars & Miranda plus Voyager 2 Neptune Encounter

Created by the Jet Propulsion Laboratory, this video, features four short productions which use satellite/space probe images and super-computer graphic animation. **17.5 mins**

An extra feature, 'Voyager 2 Neptune Encounter', illustrates the various aspects of Voyager's encounter with Neptune. **29 mins**

Space Shuttle Challenger: Accident & Investigation

On January 28, 1986, the Space Shuttle Challenger exploded 73 seconds after blast-off from the Kennedy Space Center. All seven crew members died. This video documents task force activities and findings and provides a concise, technical explanation of the cause of the Challenger accident. **29 mins**

STS-26: The Return to Flight

This video depicts the highlights of the STS-26 mission, the first launch since the Challenger accident. During the flight, the five-man crew deployed a Tracking and Data Relay Satellite. There is no commentary on STS-26 Highlights, apart from the astronauts' transmissions. The tape is accompanied by a FREE mission guide. **57 mins**

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Front Cover: **Orbiter Atlantis returns to space on 3 November 1994 after an absence of over two years during which an overhaul and extensive modifications were undertaken. See pp.100-104.**

NASA

'Newt' Space

Confronting the Future

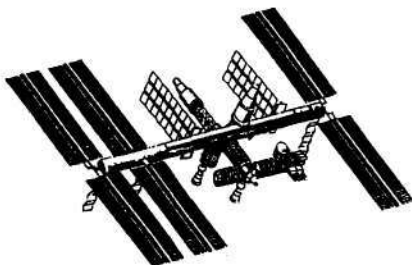
Political change entered American politics with a nuclear blast last November when the Republicans won control of Congress for the first time in more than a generation. For space policy in the United States, that dramatic political change is likely to contain both good and bad news implications. The bad news is likely to most affect NASA and those programmes and companies dependent upon the government civilian space sector for sustenance and progress. The good news aspects will be reflected most visibly in enhanced military activities and commercial ventures in space. The 'why' is obviously political (differing priorities and values) but the 'specifics' reflect the peculiarities of American budgetary politics.

NASA as Sacrificial Lamb

Newt Gingrich, new Speaker of the House of Representatives and the most visible articulator of political change, comes to office predisposed to be generally supportive of futuristic problem-solving approaches including space activities - but that enthusiasm runs into several barriers.

The famous "Contract With America" upon which many Republicans in the House ran for office is vague at certain points and is not legally binding but it clearly implies a declining federal budget except for the two social entitlement untouchables, Social Security explicitly but also medicare by implication. With tax cuts being bid by both parties for the middle class, the government's revenue flow will be depressed, meaning that money for discretionary programmes including space activities will be severely stretched as various long-established and powerful constituencies struggle to preserve their programmes.

NASA's budget is likely to be aggressively researched for "surplus" funds transferrable to other more central purposes. That pressure was coming regardless of the election outcome but the new Congress is, in principle, even more likely to cut frills, space being seen by some as a prime example - witness the close space station votes until last year. In fact, the International Space Station is likely to



'The implications are extremely adverse for the International Space Station if assured access becomes an issue.'

BY ROGER HANDBERG
Center for Space Policy and Law
University of Central Florida

be the subject of intense scrutiny and possible cancellation if the budgetary vice is tightened sufficiently.

Speaker Gingrich has already hinted in an interview reported by *Aviation Week & Space Technology* [1] that NASA will be severely tested in the new environment. His public posture is that NASA will concentrate on science and manned flight, leaving commercial endeavours for other actors principally the private sector. That situation is likely to mean a further severe curtailment of space science as the International Space Station and Shuttle absorb most of the budget left after cuts. NASA Administrator Daniel Goldin has stated that over "the last 10 years, we have had more than 1,000 launches but only 11 left Earth orbit". In the immediate future, that ratio may grow even worse if the budget crunch follows the negative curve implied in the Speaker's comments.

Space will become even more utilitarian in outlook and funding. Science will continue but at a severely reduced rate. In effect, the worsening space science budget will grow even tighter with a lengthening list of deferred and cancelled projects.

The general scenario also implies that the search for a new reusable more efficient American launcher will either fail or be dragged out - a not unusual situation in the best of times. Such a failure or delay may derail the American manned space effort for a generation. The implications are extremely adverse for the International Space Station if assured access becomes an issue.

Commercial Space: Good and Bad News

Commercial space entrepreneurs will find Newt space an exceptionally interesting time and place. NASA contracts will decline in number and value while military space opportunities will rebound from current declines. Private vendors have long criticised the heavy



hand of government, now they will be called upon to fund more basic developmental activities and take higher unprotected risks than previously. For example, if commercial interests want a new more efficient unmanned launch vehicle, they are likely to have to develop, build and, more critically, pay for it.

The opportunities to profit from space activities will be enhanced but also the chances for failure (not only will the social safety net become more tattered but also hidden and other subsidies for business will decline). The tight budget realities will make such subsidised programmes politically difficult to justify especially when companies truly intend to make money.

Republicans have historically rejected notions of industrial policy although in practice they have been more pragmatic, but the new aggressive conservatives may reject such episodes of pragmatism. Having their own money at risk, companies will demand more stringent cost accounting than occurred earlier when government subsidies cushioned or obviated economic reality and winners and losers will become more obvious.

Military Space: Good News

Military space appears by consensus to be the bigger winner although that battle will likely be more contentious than for the former two, i.e. NASA and commercial space. The reason is that the military goals espoused by Newt space require resurrecting Star Wars (the Strategic Defense Initiative) as both a strategic and tactical programme. That goal will likely bring strong counter political pressures to bear to preserve the 1972 ABM Agreement prohibiting deployment of ABM systems (both in space and on the ground). The Reagan Administration initiative has been largely discarded by the Clinton Administration on the dual grounds of continued insurmountable technical problems and the lack of a credible military threat with the demise of the Cold War.

Experience in the Gulf War, proponents argue, justifies a theatre defence capability, while opponents see

that same experience as demonstrating the unresolved technical problems. The Chinese scenario, e.g. small-scale surprise nuclear attack, by contrast argues for a limited Star Wars capability to protect the continental United States or at least its strategic assets. Such a system if proven effective could later be scaled up to the comprehensive Star Wars defence schema envisioned by former President Reagan. The technological problems remain formidable especially given the counter measures possible if such a system were deployed and the fundamental arguments are in the end likely to be budgetary as much as strategic.

Newt space is premised in large measure upon drastic reductions in domestic spending (not including entitlements) in order to fund military preparedness. Those projected cuts combined with likely tax reductions mean that programmes directly affecting the middle class are likely to feel the pinch. Whether the middle class will appreciate sacrificing their immediate benefits for what will be characterised by opponents as the dubious benefits of Star Wars in a time of peace is still to be seen.

Also, the Clinton presidency while politically crippled is not dead and the power of the president to defend his interests remains strong. A situation of protracted stalemate would reduce the likelihood of a major Star Wars expansion given that the Republican military agenda is broader than just Star Wars, amounting to the retention of a stronger in-place military capability.

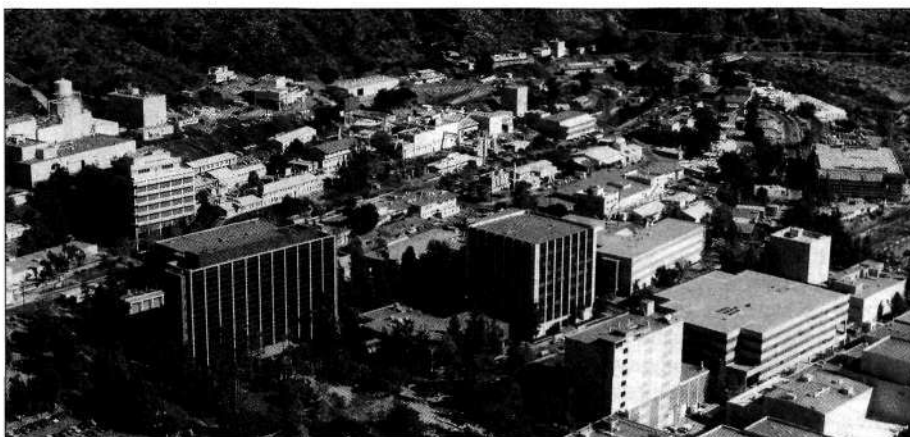
The military space programme will obviously have friends in high places as always but changes may not come as quickly as some predict.

Conclusions

Change is always upsetting to those enmeshed in the *status quo*. For NASA, the future already harsh appears to have got bleaker. Obviously, time will play out the story but the situation has become even more precarious. Civilian government space as we know it is going to change regardless, but the degree of change will now be more dramatic than expected only months ago. Commercial space interests will also find the world increasingly turbulent as they confront the realities of the marketplace. Consolidation will characterise the industry as the economically stronger absorb the weak and less competent competitors. Military space's future remains heavily dependent upon the budget outlook unless the world turns more dangerous than presently perceived. For military space, Newt space may prove a false dawn.

Reference

1. "Republicans Seek to Remake NASA", *Aviation Week & Space Technology*, 5 December 1994, p.18.



Jet Propulsion Laboratory (JPL) was transferred from Army jurisdiction to NASA in 1958 and since that time has managed the science and technology of NASA's planetary missions and has been a major participant in several international scientific missions. JPL

Process Over Product

A Disturbing Trend in Space Science

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and

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There are certain cues which indicate that trouble is imminent. When a red light glows on an instrument panel or when your mechanic says "guess what?", you can be pretty sure that you have a problem. Within the space community, contention within the scientific arena is much the same kind of indicator. Space scientists as a group have been quietly determined to make the most of the dollars and technology available, viewing challenges as opportunities rather than as problems. They now seem to be increasingly beleaguered by, and in some cases perpetrators of, a burdensome, bureaucratic process to which all space activity is beholden. This indicates that there is indeed a serious, broader problem.

Space scientists have been fortunate in that there is an abundance of worthy scientific questions which have provided a clear set of objectives common to scientists of all countries. However, although clear to themselves, few beyond the immediate space science community know or care anything about the magnetosphere, solar wind or the other seemingly exotic fields of study regularly pursued. Therefore space science has been dependent on the interest of and tied to the fate of strangers. Specifically, it has been the stepchild, in terms of both space funding and priority, to manned activity. Space science in the United States has usually received about 20% of the overall space budget. Scientists have come to understand then, that when the manned space programme fares well in funding, space science does also.

In 1979 when President Carter directed that money be put into the shuttle programme to, literally, get it off the ground, robbing Peter to pay Paul solved part of the problem. In a case referred to as the "Slaughter of the Innocents" money was taken from NASA space science projects, some of which were indeed cancelled outright, and infused into the shuttle programme. The really frustrating and

ironic aspect of this creative accounting for the science community was that since the shuttle had no space station to serve, it was largely sold to them and to political decision-makers as a vehicle for scientific research. Relatively few science missions ever materialized for the shuttle, but still the scientists managed.

Until recently this situation of being a peripheral concern within NASA priorities, although not necessarily desirable, was workable. Now, however, innovation and initiative do not seem to be enough to get the most (or even enough) from the system. Indeed the system itself, and its requirements, are the problem. Further, perhaps unknowingly, in some cases their own frustration seems to be manifesting itself by imposing exactly the same kind of restrictive, overbearing behaviour on others as they complain of suffering under themselves.

Space Science and Mother NASA

Bureaucracies are usually intended to service long-term substantive programmes as implementors of initiatives from other branches of the government: e.g. regulations concerning education, veterans' affairs, transportation, etc.

NASA as a bureaucratic agency is

an anomaly created and shaped by external forces, being mandated from its inception with tasks requiring the creation of cutting-edge technology. Further, this technology was tasked not toward improving the everyday lives of the taxpayers paying the bill, but at putting a man in space. At the time of its inception, the exploration part of the NASA mission was understandable from a political perspective, taxpayers wanted to "beat the Russians" to the Moon, but science for the sake of science has always seemed a bit esoteric to the general public.

Although its mission is vastly different from those of other agencies, NASA still must carry out its mandate within government regulations, guidelines and oversight. It was never clear, and still is not, that a civilian agency such as NASA is the best equipped in terms of R&D management processes and procurement systems to carry out the ambitious goals entrusted to it - but NASA was the politically correct answer to the challenge issued by the Soviets with Sputnik. That was then. Now, space activity is viewed as a desirable but non-essential government function, inherently costly because of the technology development involved, and very public in nature. Hence the overseeing of NASA programmes can be particularly zealous, and becoming a victim of your own success has become a real danger within the agency.

For example, when the Hubble Space Telescope ran into difficulty with the flawed mirror, criticisms of NASA were sharp and constant. NASA scientists answered the critics well, with a successful repair mission in December 1993. The mission was so successful though that NASA managers then suggested postponing the next servicing mission two years, until 1999, to save money. Their actions are understandable with "frugality" as the Washington watchword, but are hardly likely to encourage or reward the participating scientists for their achievement. Scientists are concerned that two of the telescope's cameras could fail by the time of the postponed mission - so the repair operation was a success but the patient could be left to die.

This state of affairs reflects problems which have been evolving since the Apollo years. "NASA The Bureaucracy" has been maturing and assuming all the characteristics of a classic bureaucracy; taking on its own folkways and entrenching self-perpetuation as its number one goal. In large part because of its unique history with unprecedented political support (and initially funding) for the Apollo Program, NASA was born "thinking big" and under the adage "money is no object." The public and the politicians wanted, indeed demanded, that NASA achieve the near-impossible, in the boldest, most spectacular way pos-



The new Wide Field Planetary Camera (WFPC 2) is prepared for installation in the Hubble Space Telescope during the repair mission of December 1993. This mission was so successful that NASA managers suggested postponing the next servicing mission until 1999 to save money. NASA

sible. It did its job well. The work was being done by the best and the brightest people at various centres around the United States, each specialized toward particular tasks and capabilities. Their connection individually and as a whole to NASA headquarters differed according to time and management styles, with some centres occasionally taking on the air on an autonomous kingdom. Since the Apollo years, however, it has becoming increasingly clear that scientists, managers and industry have become less of a team and far more self-protective. Most of the time, scientists have been able to persevere, often working around the bureaucracy.

Of all the various space activities, space science has long been considered the most "pure." Driven by intrinsic goals, space scientists have had few political goals to achieve, but many scientific. As a result, they have a long and proud history of cooperation, getting the most for their money, and innovation. Innovation has at times been necessary as much to conquer bureaucratic and political hurdles, as scientific and engineering ones. Scientists, for example, have had to be "creative" in the handling of cooperative projects to satisfy their respective government requirements and modes

of operation. For example, NASA requires rather detailed plans, schedules, and designation of responsibilities on cooperative ventures at a relatively early stage of the project. In Japan though, such details often coalesce only as the project progresses. During the negotiations concerning the Solar-A joint NASA-ISAS project in 1986, what became known as a *tamamushi* agreement was created to respond to the differing requirements. *Tamamushi* refers to an iridescent beetle whose colour appears to change according to the angle you look at it. So too did the agreement NASA and ISAS scientists came up with, in that it seemingly fulfilled each country's bureaucratic needs through its deliberate vagueness and ambiguity. The project went forward. In another example, during the viewing of Halley's Comet in 1986 while Cold War politics still prevailed, voice and computer communications between NASA's Jet Propulsion Laboratory (JPL) and the Soviet Space Research Institute (IKI) had to be run through the European Space Agency (ESA) in Darmstadt, Germany to avoid political entanglements. But the scientists, and subsequently the science, triumphed in both instances.

What is Different Now?

The call throughout NASA is now for "better, faster, cheaper" missions, a phrase coined by Administrator Dan Goldin. Indeed NASA has initiated a programme called Discovery designed to accomplish just that concerning solar system science. The programme goal is to maintain US scientific leadership in planetary research by conducting a series of highly focused, cost effective missions. Projects within this programme are capped at \$150 million, with fast turn-around times. The Near-Earth Asteroid Rendezvous and Mars Pathfinder missions, both to be launched in 1996, will be the first of the Discovery programme. Beyond Discovery, the entire NASA philosophy has supposedly changed to being a lean, mean, fighting machine.

The intent is admirable, the plan a sound one. Disconnects between management and scientists, scientists and engineers, and NASA and industry abound, perhaps now more than ever - or perhaps just more acutely than ever - because there is less money to be had. Some individuals feel that "better, faster, cheaper" may be mutually exclusive goals. The frustration level is high and the concern is great - if the space scientists with their predetermined goals and strong "will to live" cannot make it, it does not bode well for the rest of the space community.

Scientists argue that they are expected to do more with less, but the process is inhibiting. Indeed, they say, reducing hardware costs is often really not the issue. Fixed costs for

*'Some individuals feel that
"better, faster, cheaper"
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space flight qualification and reliability, for example, eat their budgets much like the entitlement programmes in our national budget. Scheduling is also a factor. Paying for the work to be done by the scientists and engineers becomes only a part of the total manpower costs, with a substantial amount obligated to managerial, oversight and administrative expenses. All these add to their view that much of the "better, faster, cheaper" equation is out of their hands.

One of the more interesting and complex burdens that interplanetary exploration programme managers must face is selection of launch vehicle for the spacecraft. This selection is often a process of elimination driven by the schedule of launch windows, priority of the mission and availability of a launch vehicle. Increasingly, however, scientists are under pressure to utilize smaller rockets. As mission life cycle costs become increasingly restricted, launch costs become a more significant part of the project budget and more critical in determining mission affordability. There are many launch vehicles available with cost and often risk increasing with their size. Each has a unique satellite-rocket interface for spacecraft support (mounting bracket; electrical, fluid, gaseous and environmental support; orbital transfer vehicle, etc.). Significant time (weeks, not days) and cost are involved in integrating the spacecraft with the launch vehicle. In many cases, launch vehicle costs exceed the cost of the spacecraft development and construction.

Launch vehicle reliability always enters the discussion, especially when programme managers assume the risk assessment mode. In simple terms, the real cost of space operations is the estimated programme cost divided by the combined reliability factor of the spacecraft and the launch vehicle. The price required to actually achieve mission goals can be extremely high when the launch vehicle blows up 90 seconds into the spacecraft's journey.

Industry says that "better, faster, cheaper" sounds well and good, but then, just when you thought it was safe to go back in the water, NASA put out a 700-page request for proposals (RFP) to build the Mars Surveyor spacecraft. An RFP of that length inherently implies that the specifications detail nearly the complete spacecraft design, leaving little or no room for those bidding to make innovative and efficiency oriented changes. When oversight is so intense and specifications are so tight there is little opportunity for adaptation or even examination of new technology or procedures. Apparently in the case of this particular RFP, from the Jet Propulsion Laboratory (JPL) in California, JPL and Administrator Goldin have differing views on "how much" streamlining is

Mars Global Surveyor

Mapping to Begin Late January 1998

Martin Marietta has been selected as the contractor to build the first in a series of low-cost spacecraft to explore the Martian environment after a rapid, industry-wide competition.

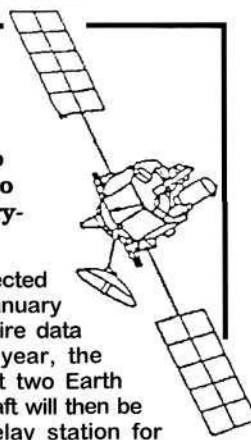
The Mars Global Surveyor is to be launched from Cape Canaveral in November 1996 to begin NASA's decade-long plan to launch orbiters and landers to Mars every 26 months to the year 2005. The rigorous timeline reflects NASA's new policy of streamlining the development and deployment of new planetary missions. The new orbiter will be a low mass, polar-orbiting spacecraft carrying all but two of the eight science instruments that were on board the Mars Observer spacecraft when it was lost on 21 August 1993. It will provide high-resolution, global maps of the Martian surface, profiles the planet's atmosphere and study its magnetic field. The orbiter will be small enough to be launched on a Delta II expendable launch vehicle and will spend 10 months in transit to Mars before entering a polar orbit around the planet in September 1997.

It will orbit Mars once every two hours, maintaining a Sun-synchronous orbit that will put the Sun at a standard angle above the horizon in each image and allow the mid-afternoon lighting to cast shadows in such a way that surface features will stand out. Mapping

operations are expected to begin in late January 1998 and will acquire data for a full Martian year, the equivalent of about two Earth years. The spacecraft will then be used as a data relay station for signals from US and international landers and low-altitude probes for an additional three years.

Mars Pathfinder

Details of the International programme of Mars missions from 1996 to 2003 appears on p.315 of the September 1994 issue of *Spaceflight*. Other spacecraft scheduled for launch in 1996 are the Mars-96 spacecraft, which is also scheduled to arrive in September 1997, and the NASA Mars Pathfinder for which a direct entry into atmosphere and surface landing is planned for 4 July 1997. On 8 September, NASA announced that the landing site would be on a rocky plain named *Ares Vallis* which lies at the mouth of an ancient outflow channel (at 19.5°N latitude and 32.8°W longitude) and was chosen for the variety of rock and soil samples it may present.



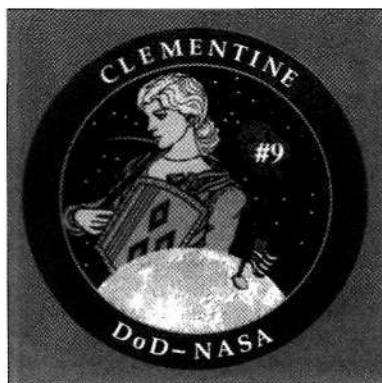
enough. For one thing, "lean" simply is not the way things have been done in the past and hence the problem with trying to change established folkways. Pragmatically, project oversight can give many JPL people a *raison d'être*, not to mention job security. This is an example of the evolving intra-NASA disconnect. There are differences among and between the NASA Centers also, in terms of responsiveness and willingness to even try to change, with JPL given relatively high marks from many university scientists who work with them. What that says about the intransigence of some of the other Centers is perhaps Goldin's biggest headache.

Dan Goldin seems almost anxious to confront some of the disconnects within the system, in or out of NASA. The \$150 million figure was provided as a Discovery mission cap, he says, yet not one proposal came in under that amount. One actually did, the Near Earth Asteroid Rendezvous (NEAR) mission, at \$112 million. Was it coincidence, greed or survival instinct that placed the rest at the cap figure? Scientists might argue that one should go for all the money available at every opportunity as one never knows what dangers lurk in the dark or when the next opportunity will come along; but that is not washing with Goldin.

Goldin says "accountability" is the NASA operating standard and that any

project that cannot come in on-time and within-budget will be instantly cancelled. To those on the government side of the fence, that means industry has to do what they say they are going to do, and not bid 60% of their desired payment for the contract and count on 40% more in changes. Clearly Goldin is serious, as in May NASA refused further funding for the Commercial Experiment Transporter (COMET) and cancelled the release of \$7.2 million earmarked in the 1994 budget. The programme is nearly two years behind schedule and over budget. Contractors said they needed another \$14.4 million to complete the first launch. NASA said no. Although funding a project to almost 96% readiness and then cancelling seems wasteful and hence unthinkable, it is that attitude that Goldin seems to feel contractors count on. Obviously they cannot any longer.

Funding for COMET was released in July 1994, after Senator Barbara Mikulski and Rep. Louis Stokes stepped in and instructed NASA to spend the full \$21 million allocated to the project. The contractors were not entirely let off the hook though, as they had to agree to sign a fixed-price contract for the first launch and accept legal liability for the re-entry vehicle, as well as several other contractual provisions which the contractors are loudly bemoaning. Goldin's victo-



'Whether "the Clementine model" can or ought to be utilised for other missions, similar or bigger, is debatable.'

ries are small but hopefully over the long-term meaningful.

When 12-15% cost overruns result in a project review and missions become seriously subject to cancellation, matching responsibility and accountability becomes imperative. As it stands now, NASA engineers may be responsible for a project spacecraft and associated costs, while university scientists responsible only for the scientific payload are held accountable for the entire project. Individuals can find themselves defending or explaining circumstances - and resulting overruns - over which they had no control, and perhaps even minimal input and knowledge.

Further, the hidden costs of operating in this new environment, such as the miniaturization of spacecraft components, and the push to include the latest technology and make it operational quickly, must also be considered. Factors such as these drive a focus on process rather than product as the cost driver. But here we seem to have come somewhat full circle. When delivering on-time and in-budget begins to be the paramount concern of the project and the science secondary, the role of the project manager changes from that of overall coordinator to assure the success of the science goals to a keeper of the ledger and time-cards. One scientist's quip, "when a project manager dies, he goes to a heaven where there are no scientists," conveys many scientists' perspective of the current situation - that science has become simply a nuisance in the way of the all-important process.

A New Model?

Here enters the new kid on the block, Clementine. Developed by the Department of Defense Ballistic Missile Defense Office (formerly the Strategic Defense Initiative Organization), the spacecraft is a test vehicle for leading edge technology lightweight sensors and control systems. This small spacecraft has a dry mass of 227 kg with an equal mass for fuel. Clementine was launched on 25 January 1994 and completed over three hundred lunar orbits as of 3 May 1994. Unfortu-

nately, enroute to rendezvous with near-Earth asteroid 1620 Geographos, its thrusters misfired due to a computer glitch, sending it into a furious spin. Initially it was thought that the misfiring and subsequent use of all the thruster fuel meant that the asteroid intercept would be impossible. Then, firing the main engine for orientation was thought to be possible. Later discussions turned to retargeting Clementine to an Earth orbit. In any event, based on the lunar data already received, the mission has been declared a huge success.

During lunar orbit Clementine transmitted over 1.6 million images. During one particular orbit Clementine was given a matrix of parameters for observation. Within this matrix Clementine autonomously "planned" the mapping pass, turned on sensors, calibrated sensors, completed the planned imaging adjusting and optimizing sensors where required and transmitted the data to Earth.

Key elements of the Clementine Organization include a small team of DOD, NASA and Industry personnel, construction of vehicle at the US Naval Research Laboratory (NRL) in Washington DC and construction of the sensor, attitude control systems and software at Lawrence Livermore National Laboratory in California. NASA provides communication through a tie into the Jet Propulsion Laboratory's Deep Space Network. Actual command and control of the spacecraft and initial handling of data is accomplished in a small building in Arlington, Va., known as the "bat cave" using PC based software. The current estimated total cost of the Clementine spacecraft, started in late 1990, is \$80 million. It should be noted, however, that adding the cost of equipment developed separately, such as the miniaturized cameras, would increase the total cost of the mission substantially.

Clementine is unique in that the small programme management team sought out and incorporated commercially developed technology, rather than equipment designed and manufactured under the costly military specifications system - or "milspecs" - typical of most military programmes. Having been built in a national laboratory rather than by private industry also separates it from other similar programmes. But first and foremost to those who look at it as a model, it was launched on-time and in-budget, a true

One fundamental question that seems to emerge from this entire process-versus-product dilemma is "how much science is enough" from a mission?

rarity of late, and has yielded new and valuable scientific data about our nearest neighbour in space.

Whether "the Clementine model" can or ought to be utilized for other missions, similar or bigger, is debatable. Several credible arguments have surfaced. Some analysts feel Clementine's science was simply accidental; a by-product of its military mission to test the durability of lightweight sensors and components. Another argument against the Clementine model observes that it stifles private industry incentive and opportunity to expand their functional technology bases by using the national laboratories to build demonstration spacecraft. Many space scientists say that they do not care how it was done, just that it was done and shows the potential for more. The future of the Clementine programme itself may be in jeopardy simply because military space programmes are not in favour with the Clinton Administration.

The Future?

One fundamental question that seems to emerge from this entire process-versus-product dilemma is "how much science is enough" from a mission? It is a question with which scientists themselves must grapple, having both pragmatic and philosophical aspects. The fear is that if you accept less than "everything", whatever is accepted will become the standard for the future. With history to learn from, that is not an unrealistic concern. On the other hand, holding out for 100% could make you sole owner of 100% of nothing.

So what do we do? Can we afford to qualify the latest technology for space operations or shall we just make do with what is already qualified? The fact is that smaller and faster can be significantly more expensive. Short of attaining access to space on demand this is where we are stuck, so NASA must focus on supporting the following: economies of scale, reduction in bureaucratic hurdles, the most flexibility possible in RFP's, integrated science and engineering teams, reduction in the infrastructure for oversight and placing that responsibility squarely on the programme manager and his development team, reduction in guarantee requirements and recognizing that sometimes failure is an enabling objective. This is true not just in space science, but the entire space programme.

It will most probably be left to the scientists, however, to lead the way. The aim of reaching into space because we can and because we can learn must not slip away because of arrogance or too grandiose ideas. There is a difference between vision - foresight mixed heavily with imagination - and hallucination, where desires have nothing to do with reality. ■



President George Bush delivers his speech at the National Air and Space Museum honouring the 20th anniversary of Apollo 11's landing on the Moon. Also pictured from left to right: Apollo 11 astronaut Neil A. Armstrong, Vice President Dan Quayle and Apollo 11 astronaut Michael Collins. NASA

Doomed to Fail

The Birth and Death of the Space Exploration Initiative

On July 20, 1989, while marking the 20th anniversary of the Apollo 11 lunar landing, President George Bush stood in front of a giant American flag at the National Air & Space Museum in Washington, DC and proposed a bold new programme of human exploration of space. America should return to the Moon to stay and send humans to Mars, Bush said, citing destiny and America's need to lead the free world. To those in attendance, it sounded as if the Apollo Program was back.

But just four years later, with a new President in the White House and a lot of new Congressmen on Capitol Hill, NASA closed the Office of Exploration charged with carrying out the ambitious plans laid out by Bush.

Stillborn

The decision had little to do with the new administration or the fiscal-mindedness that swept Congress, for Bush's Space Exploration Initiative (SEI), as it was known, had been stillborn. In four years there had never been enough support to start even a series of modest precursor missions to map the surface and resources of the Moon. Indeed, in fiscal year 1993, the Office of Exploration's request for a mere \$5 million was struck down by Congress and, as lunar scientist Dr Wendell Mendell noted, Congressional staffers had pored through NASA's budget and deleted programmes that even *sounded* as if they were part of SEI. Because of the political devastation caused by this proposal, the United States is probably farther away from a return to the Moon today than it was almost six years ago.

But why did the Space Exploration Initiative fail? Why did the first clear articulation by an American president of a future for the United States in space gather so little steam? There are almost as many answers to this question as there are critics of the space agency. If ever one wanted a perfect example of how *not* to enact a major new federal programme, SEI would do nicely. Just about everything that could be done wrong was done wrong, and it is clear that there is more than enough blame to spread around, both inside and outside of

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NASA. Lacking a Cold War justification, Bush's bold new plan to return to the Moon fell to politics as usual in Washington.

STG's Report Meets its Fate

The origins of SEI are open to interpretation. Back in 1969, the Space Task Group, a special panel called together by President Nixon consisting of Vice President Spiro Agnew, NASA Administrator Thomas Paine, and Secretary of the Air Force Robert Seamans, proposed that after Apollo the nation should pursue a broad-based space exploration programme that included a space station, a lunar base, Mars exploration, and a space shuttle. In many ways this was a carbon copy of a vision first established by Wernher von Braun in a series of articles in *Colliers'* magazine and a later series of Disney films in the mid 1950s. The von Braun vision was that the only space programme that made sense was one that attempted to do everything simultaneously - go to the Moon *and* Mars and build a space station to serve as a jumping-off point. All of this would be serviced by a space shuttle.

The Space Task Group's final report

had been watered down somewhat so that the proposal was not presented as a recommendation for the president, merely an option. In fact, Paine had deliberately ignored the earlier report of Nixon's transition team on space, which had recommended that NASA continue lunar exploration and specifically warned against setting a Mars goal. Instead, Paine had lobbied Agnew to endorse the broad vision of an expanded human space effort in the view that the vice president could then convince Nixon.

But how the STG's report was presented ultimately did not matter: President Nixon was no space enthusiast and Agnew had no clout in the White House. While Nixon was a big fan of the astronauts and their exploits, neither he nor his closest aides saw space as offering any real political value to his administration. Nixon only endorsed the station and shuttle goals - ignoring the Moon and Mars - and later deferred the station indefinitely. Indeed, by 1970, the administration was looking at the possibility of cancelling Apollos 16 and 17 and Nixon only reluctantly agreed to the space shuttle out of a belief that it served national security interests and would win him votes in California, where most of the money for the project would go. He also had a desire not to be the president who ended the American man-in-space programme. Talk of returning humans to the Moon and sending them to Mars disappeared for almost a decade as NASA concentrated on getting the shuttle flying.

Jimmy Carter used the occasion of the tenth anniversary of the lunar landing to push his energy program. He, like his predecessors, was not interested in space. He had better uses for the money.

Searching for a Space Policy

In the early 1980s, a group of graduate students at the University of Colorado in Boulder, calling themselves the "Mars Underground," held a series of conferences called *The Case for Mars*. These conferences brought together scientists, engineers and enthusiasts from all over the country to discuss the possibility of sending humans to the red planet. They managed to energize the space community and give human exploration of Mars a certain degree of visibility. Others, including Carl Sagan and the Planetary Society and the late Senator Spark Matsunaga of Hawaii, endorsed the idea of a joint US-Soviet mission to Mars as a means of ending the Cold War. During the same time, a group of scientists at NASA's Johnson Space Center in Houston started studying potential concepts for lunar bases.

By the mid-80s, the lack of clearly defined goals in the American space programme was apparent to a

number of key policy makers in Washington and Congress created the National Commission on Space to address the issue. The Commission was originally to be chaired by former NASA Deputy Administrator George Low, well regarded as a level-headed pragmatist. Unfortunately Low died before he could chair the committee. Former NASA Administrator Paine was named in his place. Paine had been administrator during the Moon landing and had been instrumental in determining the shape of the Space Task Group.

If the American grass roots interplanetary movement had a leader it was certainly Thomas Paine. Paine was well-liked by the Mars Underground and other space activists because his passion was Mars and he made no attempts to conceal that fact, either as NASA Administrator or in private life. Paine was smart and had a sly sense of humour. He was fond of pointing out that the nation spent more on Space Invaders than the space shuttle, that it spent more on pizza than the entire space programme. But while true, these figures were largely irrelevant. In themselves they were not justifications for spending more money on space exploration.

Paine's biggest flaw was that he knew nothing about Washington, and, as many Washington policy makers later confided, his selection to chair the committee all but determined the outcome of the National Commission's report. The report, *Pioneering the Space Frontier*, was more of a broad-based endorsement of the extensive human exploration of space than an evaluation of the options available to the nation. It depicted lunar bases, Mars missions, a large space station, nuclear spacecraft and aerospace planes. It was lavishly illustrated by space artist Robert McCall and endorsed increased spending on space exploration through effectively doubling NASA's budget. It was an expansive - and expensive - view of the next fifty years in space, but it was more fiction than a realistic blueprint for current policy making.

Congress recognized this too and charged the NASA administrator, James Fletcher, with responding to the National Commission on Space Report. Although Fletcher certainly had his faults, he understood the political workings of Washington better than Paine and gave the task to former astronaut Sally Ride. Ride responded with another report, *Leadership and America's Future in Space*, which acknowledged that there was a wide gap between the vision of *Pioneering the Space Frontier* and the reality of the Challenger explosion. Ride's report outlined four possible directions for the United States: a human mission to Mars, a lunar base, extensive robotic planetary exploration, and "Mission to Planet Earth," a study

of the Earth's changing climate.

Although Ride in some ways had merely repeated some of the same themes present in the earlier studies, she was astute enough to note that these could be separate paths and that they could be pursued to different degrees—neither the President nor the Congress had to endorse the entire framework. The one idea that did receive broad support in Washington was the Mission to Planet Earth proposal, which came about at a time of increasing concern with such environmental issues as global warming and the ozone hole. Many in Congress viewed this as a more relevant proposal capable of having an impact on the way people on Earth lived.

Ride did not write her report alone. It was actually partly the product of the Office of Exploration, created by Administrator Fletcher three months earlier at NASA headquarters. But the office was not very large and consisted of little more than Ride and some support staff. She soon retired to private life and Aaron Cohen took over the operation of the office. Cohen came to headquarters from Johnson Space Center in Houston, where they had been conducting lunar base studies for several years. Johnson, as the astronaut training centre and site of Mission Control, had a vested stake in human spaceflight, particularly involving the shuttle. For the next two years the office, known as "Code Z" and under the authority of an Assistant Administrator, conducted several studies of lunar and Mars exploration missions, labelling them part of the "Human Exploration Initiative." Code Z's studies involved the use of a large new booster based on the shuttle, known as "Shuttle Z." The Shuttle Z would not be cheap to operate, but NASA engineers were not concerned about costs. They figured that once the political word was given, the money would begin pouring in.

In February 1988, the Reagan administration issued a national space policy document that called for the "expansion of human presence beyond Earth orbit," tacitly endorsing human missions to the Moon and Mars. But Reagan was not in office long enough to actually have to pay for such an endeavour and, other than continued studies by Code Z, nothing further came of this new position. In November 1989, George Bush beat Michael Dukakis to become the forty-first President of the United States.

Space Council Recreated

Clearly there had been much talk about human exploration both inside and outside the government. But talk is cheap and none of these various offices or commissions can truly claim credit for SEI. The origin of the idea seems to lie with several of Vice President Quayle's advisors and Budget Director Richard Darman. Quayle was

given the position of Chairman of the National Space Council at least in part to boost his visibility, although several of his friends warned him of the dangers of becoming known as "Mr Space." His staff viewed this as an opportunity to improve the image of their much-maligned boss and convinced Quayle that the US should endorse a large space mission. Darman, who was an enthusiastic space advocate, also supported the idea. But the actual fleshing out of the idea was done by someone else, someone who also had something to prove. That person was a mid-level bureaucrat named Mark Albrecht. Albrecht was named to be the Executive Secretary of the newly created National Space Council.

The Space Council was another one of those ideas for better policy-making that periodically resurfaces in Washington circles. Lyndon Johnson had created the first Council as part of the Act which created NASA, but Eisenhower had ignored it. Vice President Johnson had later used his position as head of the Council to push Kennedy into the lunar goal. But the Council had languished under both the Johnson and Nixon administrations and was finally eliminated in 1973. The idea of re-creating the Council had been endorsed by the National Commission on Space, which viewed it as a means of gaining high-level attention for space issues. It had also been a popular idea in Congress, where the Reagan administration's secretive space policy process, hidden in the National Security Council and heavily dominated by the Defense Department and Intelligence Community, was viewed with suspicion and resentment. It had *not* been a popular idea with Reagan, who went so far as to veto a NASA authorization bill which included language creating a space council. Reagan had objected to Congressional intrusion in the policy-making process. By 1989, Reagan was headed out, the language creating the Council had been watered down, and Bush indicated that he supported the idea, in part because it would give his Vice Presidential running-mate, Dan Quayle, a visible role in policy-making.

Although the Space Council was officially chaired by Vice President Dan Quayle and included many top cabinet officials, it was the Council's Executive Secretary and small staff that helped shape policy and define issues to be addressed by the full Council. Albrecht was not the first choice for the slot but was offered it after General Henry Cooper was rejected out of fear that he might be unjustly linked to the innuendo and hearsay that had surrounded the nomination of Bush's defense secretary John Tower. Supposedly, someone had reported seeing Cooper, who was about as strait-laced as they come, in Vienna in a compromising position. The rumour proved totally false, but the last thing

that anyone wanted was another nasty nomination fight and so Albrecht was quickly offered the job. Cooper went on to head the Strategic Defense Initiative.

Albrecht had little space experience, having addressed mostly national security and intelligence issues as a Congressional staffer. Despite this, he proved himself capable very early on in the job by solving a funding dispute concerning the remote sensing satellite Landsat. Albrecht wanted to make a name for himself in the space community and also wanted to provide a sense of purpose for the failing space agency. From his appointment in March 1989, Albrecht began searching for a new project to galvanize the civilian space programme. Quayle's advisors were already talking about such a project and Albrecht and the Space Council quickly thrashed out three proposals: a return to the Moon, a human mission to Mars, or a commitment to do both.

Policy decisions in Washington rarely start with a Presidential directive. Instead, issues are brought to the attention of senior leaders by staffers who then order further study and request information and recommendations. Albrecht's campaigning for human space exploration is therefore nothing unusual. But it did not follow the Apollo model, where both Kennedy and Vice President Johnson, as chairman of the National Aeronautics and Space Council, were predisposed from the outset toward a major space project in response to Sputnik. Kennedy was also surrounded by a number of other enthusiastic space supporters. In contrast, Kennedy's predecessor, Eisenhower, had once taken his NASA administrator out into the Rose Garden and pointed at the Moon and said "That Moon is going to be up there a long time." There was no rush to get there. Neither Bush nor Quayle were very interested in space, but neither were they hostile to it. Quayle took the proposals to Bush, who decided to pursue both the lunar and Mars goals simultaneously.

Bush: Advocacy Without Strength

This fact in itself explains part of the reason why the decision to return to the Moon failed: Bush was never an enthusiastic supporter of the programme. He was never willing to risk political capital to push the programme or even give it modest attention. In many ways, Bush was an advocate of space exploration in the same way that he was "the Environmental President" or "the Education President"—weakly, and in name only. On the 20th anniversary of the lunar landing at an extravagant and nationalistic ceremony at the Smithsonian, Bush praised the Apollo 11 astronauts in front of a giant American flag and models of the lunar lander and Saturn V rocket. Then he outlined his own

'Many of those drawing up plans for lunar and Mars exploration never really answered the question of why it should be done.'



First on Mars. This shows a hypothetical view of the first human landing on Mars. In this conception, a supply ship landed first in the background, followed by the lander carrying a crew. The landscape is based on photos and data from Viking and other spacecraft, and on sketches from nature in the deserts of Arizona and Sonora.

PAINTING BY WILLIAM K. HARTMANN

programme.

Bush's speech was immediately widely criticized on Capitol Hill, where House Majority Leader Richard Gephardt quipped, "Mr President, there's no such thing as a free launch," and others blasted the rumoured \$300 billion price tag for such an undertaking. The Democratic Congress, in many ways chastened by Bush's decisive victory and extended honeymoon, saw this as merely another chance to embarrass the president.

Once the goal had been outlined in Bush's July speech, there came the task of carrying it out. Presidents cannot simply endorse large projects and then expect them to enact themselves. The president must be a strong advocate of the programme. Occasionally, his intervention is necessary at key decision points and during major Congressional votes. For reasons which still remain vague, Bush did not do any of that. But there are three good explanations which may explain why Bush never got firmly behind the Space Exploration Initiative. First of all, Bush's endorsement of SEI may have been like his weak endorsement of a whole series of things that he later abandoned - opposition to tax hikes being the most egregious example. Columnist George Will, as one of Bush's harshest critics, said of the President, "he means well... feebly." Secondly, Bush may have never been truly committed to a programme that he did not think up in the first place. Often criticized for a lack of vision, this may have been a case where the vision of his staff simply did not rub off on the president. Finally, Bush may have been ill-served by his subordinates, both on the National Space Council and in NASA. NASA in particular responded to Bush's proposal with

a programme plan that was so expensive and provided returns so far in the future that there was little reason for the president to support it.

The Space Council never had very good relations either on Capitol Hill or with NASA. It was viewed by both, correctly, as an attempt to take space policy-making back from those two entities and return it to the White House. While the concept of a Space Council had been generally appealing to Congress in the abstract, in reality it proved little better than the process it replaced. Furthermore, Council staffers had a rather antagonistic relationship with Congressional staffers, who often complained that they could not get their phone calls returned. NASA, on the other hand, was a mess and openly hostile to the entire programme plan. NASA administrator Richard Truly, a former astronaut, was not terribly enthusiastic about going to the Moon and was primarily concerned with flying shuttles and building the space station. He was only willing to accept the programme if it required the shuttle to do practically everything.

NASA's response to Bush's speech was the "90-Day Study." This was presented to the Space Council in November 1989. It was intended to serve as a roadmap for SEI - a list of what to do and when to do it. As a policy document, it proved to be a total disaster. Reportedly, Truly ordered that the dollar figures be removed from the document before it was presented to the Space Council, but word quickly got out that the cost would be \$300-\$400 billion over thirty years. This meant doubling NASA's budget immediately, from about \$11 billion a year to \$22 billion a year and maintaining it for the next three decades. They were essentially Apollo spending levels. But NASA did not have the threat of a

Russian Moon programme to worry about.

Unrealistic NASA

NASA, like all government agencies, has to deal with different internal and external constituencies, each clamouring for its own priorities. The space agency is rather unique in this regard in that its facilities are spread throughout the country at various field centres, each of which represents different interests - human spaceflight at Johnson, robotic exploration at the Jet Propulsion Laboratory at Pasadena, for instance - and each having clout in Congress. In addition, NASA has also had somewhat of a rivalry between its scientists, who want to collect data, and its engineers, who want to build equipment. In many ways, the "90-Day Study" was a reflection of the conflict within the agency and the lack of strong leadership from Headquarters. It typified the *Apollo Paradigm* which had come to dominate the agency whereby everything at NASA was approached like the crash programme to put a man on the Moon - requiring huge amounts of personnel and large expenditures of money.

What NASA did was to simply wrap up every project on its wish list and put it in the report. As a result, the report contained everything from Lunar Observer, a robotic lunar probe (\$700+ million), to a Mars rover/sample return mission (\$10 billion). It included an early version of MESUR (Mars Environmental SURvey), a distributed network of probes on the Martian surface, using two expensive Titan IV boosters. But the truly big ticket items were an extensive lunar base and a Mars base, using both the shuttle and a shuttle-derived heavy lift booster. They would use the space station as a jumping-off point, even though there were many station supporters who warned that this was not only unnecessary but could jeopardize other station missions like delicate crystal growth experiments. Some of those involved in the study found the whole process bizarre. One of the requirements for the lunar base was a crane for lifting cargo off the landers and depositing it on carts to be wheeled to the base. The accountants went to work and came back with a price tag for the crane - ten billion dollars. . . for a crane.

One of the more astounding projections in the report called for 14 shuttle flights a year in support of the programme. This would have exceeded the maximum flight record of nine shuttle flights in a year and may have required the construction of an additional large launch pad at Cape Canaveral. Just as importantly, it did not include any other non-SEI missions. In other words, to pursue SEI, NASA was virtually proposing to abandon everything else on its plate, including the politically popular Mission

to Planet Earth, while at the same time doubling its budget to carry out the new mission. But Admiral Truly wanted to fly shuttles and so the agency came up with a mission plan that would have required lots of them.

If NASA had wanted to discredit the Initiative, it could hardly have done better than the 90-Day Study, which landed like a bomb in Washington and confirmed the suspicions of critics in Congress that the president was endorsing a multi-billion dollar programme at a time that budgets were getting increasingly tight. A programme plan that required doubling the space agency's budget indicated either that the mission was impossible to accomplish cheaply or that NASA was too screwed up to do it. Neither conclusion bode well for the future of SEI.

Indeed, some on the Space Council were shocked by how unrealistic NASA's study was and privately expressed dismay. It was in response to the 90-Day Study that the Space Council convened a special blue-ribbon panel to review this and several other proposed plans. One of the plans came from Lowell Wood, a scientist at Lawrence Livermore and protégé of Edward Teller who was known as the creator of Brilliant Pebbles. Wood's proposal involved inflatable spacecraft and the use of other unconventional techniques. It would have bypassed NASA completely and relied on ignoring traditional government procurement procedures. Wood's estimate was that such a programme, including the Moon and Mars, could be done for around \$10 billion in 10 years - the cost of NASA's lunar crane. But a former Space Council staffer admitted that they pushed Wood's proposal to "scare the pants off of NASA."

The blue-ribbon panel consisted both of space experts like Carl Sagan, Buzz Aldrin and policy analyst John Logsdon, as well as others brought on to add intellectual diversity to the panel, such as Edward Teller and Tom Clancy. Faced with NASA's \$400 billion proposal on the one hand and Wood's \$10 billion proposal on the other, the panel determined that more study was needed. Many members were also critical of NASA for what they viewed as a totally unrealistic approach. The panel recommended that the National Academy of Sciences study the issue further.

In NASA's case, the policy process is complicated by the fact that many of the people involved in the community are engineers with little understanding of politics. Either they view politics as illegitimate, and a corrupting influence on the task of setting goals for the space programme, or they feel that political justifications can be handled logically and empirically, like thermodynamics. Many of those drawing up plans for lunar and Mars

exploration never really answered the question of *why it should be done*. In most instances they did not even try, taking an attitude somewhat akin to, "just sign the cheque and let me go play." But while they may have failed to answer the question of why, they also fell down when it came to the question of how - the question they should have been far more capable of answering.

A well-balanced programme plan should have offered the President multiple options with varying price tags. But the 90-Day Study did nothing of the sort. It simply offered five different ways of doing essentially the same expensive mission. Some of the "reference approaches," as they were called, were difficult to distinguish from one another and looked as if the study team had made little effort to offer a range of alternatives. The message seemed to be: conduct SEI like Apollo or not at all. But an Apollo-type programme was totally unrealistic after the Cold War and only the rocket-scientists failed to recognize it.

SEI Damaged

Thus began a long process of what official Washington is best at: studying a problem to death. But the problem was not with the people ordering the studies, it was with the results that the studies produced. None of them adequately reflected reality - there simply was not enough money out there to conduct a large human space exploration programme. In order for there to be more money, Bush would have had to been willing to fight for it and the total dollar figures would have had to be far lower than they were. But the initial response had not been good and the damage had been done. Almost immediately everyone started talking about a \$500 billion boondoggle. The high numbers themselves may have scared Bush away and led him to think that the programme was a liability.

In May 1990, at the impetus of the Space Council, Project Outreach was begun. This was an attempt to appeal for outside suggestions concerning how best to conduct the Space Exploration Initiative. The panel appointed to collate the proposals was to be known as the Synthesis Group and was chaired by former astronaut Thomas Stafford. Project Outreach was a clear indication of the Space Council's total lack of confidence in NASA's approach to SEI. It was another indication of the growing war between Albrecht's Space Council and Truly.

Other factors also intervened to damage SEI. One of the major problems was that Truly actively campaigned in private against a programme that his boss, the President of the United States, had endorsed in public. When queried in Congressional hearings on what sectors of NASA's budget could be cut, Truly pointed to

SEI as something he was unwilling to fight for.

As time went on, NASA's image worsened. In the summer of 1990 the agency suffered a series of setbacks, including hydrogen leaks on the space shuttle and the Hubble Space Telescope's flawed mirror. This prompted Albrecht to urge Quayle to call for an outside review of the space programme. The review, the Advisory Committee on the Future of the US Space Program, was headed by the Chairman of Martin Marietta, Norman Augustine. The Augustine Committee, as it was called, issued its report in December 1990, concluding that the civilian space programme was not in as bad shape as its critics charged, but did urge that the space programme be refocused to make science the centre of its mission.

One thing the Augustine Committee did not do was to differentiate between science and exploration, which might have bolstered the argument for humans in space. Neither did it issue a ringing endorsement of the SEI Program, which it relabelled the awkward-sounding "Mission From Planet Earth." In fact, as Quayle later revealed in his memoirs, the Augustine Committee initially placed human exploration last on the list of missions that NASA should be occupied with. Quayle, Albrecht and others objected and so the listing was eliminated from the final report. What the committee did do was to propose that NASA adopt a "go as you pay" approach to human exploration of the Solar System and that NASA create a position of Associate Administrator for Exploration. "Mission From Planet Earth" would be open-ended and without a timeframe and NASA should only propose missions it could reasonably expect to be funded.

Death-Throes

NASA's response to the Augustine Committee's report was weak. Richard Truly did name an Associate Administrator for Exploration. His name was Michael Griffin and he came to NASA after a successful stint in the Strategic Defense Initiative Organization. But although Griffin brought a new approach to SEI, a "smaller, faster, cheaper" approach, he antagonized many in Congress. Selling an unpopular programme on Capitol Hill was a lot different from managing a secret experimental satellite. Griffin also failed to communicate well with the head of NASA's Office of Space Science and Applications, Leonard Fisk, and they both ended up proposing redundant programmes on Capitol Hill, making the agency look even more foolish.

In the summer of 1991 the Synthesis Group issued its report which in some ways was a further disappointment to SEI proponents. *America at the Threshold* was another

glossy report illustrated by Robert McCall. It was focused more upon architecture and infrastructure - the ways of conducting exploration missions - rather than the why or the ways of reducing the costs. The report stated that both Mars and lunar missions required a heavy lift launch vehicle on the order of the Apollo mission's Saturn V - an expensive undertaking. Furthermore, the report strongly favoured the use of nuclear propulsion to send humans to Mars. In essence, what the Synthesis Group said was that there were no cheap routes either to the Moon or Mars. There were no truly groundbreaking ideas floating around which would make SEI possible. The Space Council had hoped that an outside group could gather cheaper ways to do what NASA said would be incredibly expensive. It failed to do this.

The release of the Synthesis Group's report led Space Council Chairman Dan Quayle to state that the end of the shuttle programme was in sight. This resulted in a minor public spat with Truly, who was still pushing the idea of purchasing a fifth space shuttle in addition to the one already on order to replace the *Challenger*. The public dispute between Truly and Quayle was only the tip of the iceberg, because by this time Space Council staffers were actively attempting to get him fired - apparently without Quayle's knowledge. The problem was that Bush had shown a great reluctance to fire agency and Cabinet heads who were damaging him politically or even actively opposing him. In many ways the President was more loyal to his subordinates than they were to him. Truly was also extremely adept at Washington infighting and craftily deflected attempts to fire him by using both the press and his relationship with the president. Although Truly had been Sununu's choice (another person Bush had a hard time getting rid of), Truly acted as if he and the president, both former Navy fliers, were close personal friends. The whole affair got incredibly messy. After the decision had been made to fire Truly his wife even wrote Bush a letter pleading that her husband not be fired. As long as Truly hung on, the Space Council was unable to push NASA towards a workable SEI plan.

Furthermore, the situation at the space agency seemed to worsen as there were problems with both the Galileo space probe and a NASA-managed project to build the United States' next generation of weather satellites, not to mention continued management and design problems with the space station. In the spring of 1992, Bush finally did fire Truly in a messy and embarrassing way. The person they got to replace him was Dan Goldin, who has been fighting to reform the agency's bureaucracy ever



since. But by this time the point was moot. The Space Exploration Initiative was dead.

Why did SEI Fail?

Some critics say that the whole idea was unworkable right from the start. Even if NASA had not been in the terrible shape it was in 1989, even if Bush had been willing to throw greater weight behind the proposal, even if the Space Council enjoyed amicable relations both with Congress and NASA, the cost of a Moon-Mars programme was simply impossible. NASA already had a space station programme waiting in the wings, there was no way it could handle two multi-billion dollar development programmes at once. But others, like space policy analyst John Pike of the Federation of American Scientists argue that if NASA, the Space Council and President Bush had all done a better job of justifying the programme, it might have had a greater chance of being implemented.

What is somewhat ironic about the whole sordid mess was that after all the damage had been done and after Congress refused to appropriate even minimal amounts to continue paper studies, NASA finally came out with the first part of a workable SEI program plan. Known as First Lunar Outpost and unveiled in 1992, the NASA plan would return a four-person crew to the lunar surface for an extended stay. The scientist-astronauts would conduct astronomical and geochemical experiments as well as evaluate the use of lunar materials for on-site support of future missions. First Lunar Outpost, or FLO, as it was called, would still require a Saturn V class booster and would still have a hefty price tag, but it represented significant progress toward a workable plan. Furthermore, FLO was a "go as you pay" approach, since it was only the initial step to a permanent return to the Moon, not a giant, multi-billion dollar leap.

At the fourth *Case for Mars* conference in 1990, Air Force Colonel Pete Worden, who worked both in SDIO and on the Space Council during its war with NASA, managed to sum up what by that time had already gone wrong. Worden said "Our final piece of political advice from those of us involved in SDI: For everyone's sake, make sure you know exactly what and when you want to build before you have the president give a speech on it." ■

Space Station

A Social Science Perspective

We note with interest that Dr Michael Fulda a Member of the BIS appeared before a Subcommittee of the US House of Representatives on 5 May 1994 to present a statement on US-Russian Cooperation in human space flight relating in particular to the International Space Station.

Michael Fulda writes about the work of his institute which is devoted to the study of the relation between man, society and space and sends us details of his statement to the Subcommittee.

Although space social scientists may disagree among themselves on the details surrounding human space flight, they would staunchly defend its existence when faced with the threat of cancellation. For this reason most of them are likely to support the Space Station as they feel that its cancellation would lead to the cancellation of the entire US Human Space Program. Indeed, they would be opposed to the redistribution of Space Station funds among competing domestic programmes. By their training and temperament, social scientists are not insensitive to veteran's health care programmes or to the housing needs of the lower income population, but would urge serious examination of alternative financing mechanisms to these pressing needs.

US-Russian Cooperation

The agreements recently signed between the US and Russia dwarf all previous international space agreements in their scope and purpose. Cooperation on the Mir and Alpha space stations and their required space transportation portend the practical merger of both countries' human space programmes into the foreseeable future.

The justifications for this cooperation have rested on space policy (in that we can learn from Russian design and operational philosophies), budgetary policy (cooperation will avoid duplication, leading to cheaper and faster programmes) and foreign policy (cooperation in the one major civilian area where both partners are equals may lead to cooperation in other domestic and foreign policy areas). These justifications are presumed to outweigh the risks involved in this joint venture.

The Recommendations

To the US House of Representatives Subcommittee
5 May 1994

Independent Studies: that the Subcommittee and the full Committee have the authority to commission pertinent studies by Congressional Agencies and that they also have the influence to motivate NASA and departments and agencies of the foreign affairs and national security communities to commission studies by independent

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The main risks involved are technical (as in all space programmes), managerial (how to coordinate/integrate two teams with different technologies and management styles), domestic policy (changes in priorities may lead to cuts in budgets), and foreign policy (worsening of relations elsewhere may spill over into space relations). In addition one must consider the loss to the US of aerospace employment and technological capabilities.

Risk Assessment

The above categories of risks are enlarged upon as follows:

Technical

In this area the main social science contribution is in assessing the impact of interpersonal and cross cultural behaviour on the design and operations of the joint programmes. While both the US and Russia have substantial experience in training and hosting foreign cosmonauts and astronauts who, mostly during brief flights, had to conform to the requirements of their hosts, there is almost no experience in the joining of programmes of equal partners for long duration missions. Space station operations, partly justified on grounds of political symbolism, cannot afford the risk of being exposed to preventable, highly publicised squabbles.

Managerial

Complex technologies, such as

ent sources such as the National Research Council and the National Academy of Public Administration.

Independent Research Institute: that a topic for one of those studies should be the desirability and feasibility of creating an independent research institute devoted exclusively to studying and evaluating US-Russian space relations, not only in their technological aspects, but also in their entire organisational, social, legal, cultural, economic, political and diplomatic context.

those found in the space programme, are as much a product of superior administration and management as they are of science and engineering. US-Russian space cooperation, especially in the Human Space Program, has clustered at the top political and managerial level for the forging of agreements and the coordinating of policies, and at the working level to integrate products and procedures. According to articles in the trade press there is a substantial gap of information and coordination at other levels and in support organisations. This contributes to a mutual sense of insecurity in this joint venture.

Domestic Policy: Russia

Russia is undergoing the experience of three simultaneous, traumatic changes: the breakdown of the Soviet empire, free market reforms and democratisation. The resulting massive social, economic, and political instability has had a substantial impact on the Russian space programme. Russia has had to come to terms with Kazakhstan concerning the Baikonur launch complex and with Ukraine and Bielorrussia concerning production, delivery and methods of payments for space hardware produced in the former Soviet Union. The process of democratisation has led to changes in foreign and military policies which are forcing a military and industrial conversion process reminiscent of that of vanquished nations after World War II. The major social and political problems caused by this conversion are largely responsible for hyperinflation, itself a major cause of instability. Free market reforms, to the extent that they produce a loss of production, unemployment and a widening of the gap between rich and poor, are also a source of short range instability.

The interactive effects of these multiple causes of instability on the Russian space programmes are impossible to predict. False predictions over the past few years, such as widespread famine, government or private nuclear proliferation, or the disintegration of the space programme, are a reminder of the pitfalls of prophecy. But social scientists in the pertinent disciplines may rightfully question the assumptions of policies based on present predictions. Two examples follow.

It is assumed that, given past and (somewhat diminished) present political support, a future Russian democratic regime will continue to support its human space programme. This superficial assumption ignores the political and psychological context of the past - an authoritarian regime where citizens had no voice on government policy, or of the present, a condition of relative anarchy, where the average citizens feels disconnected with most government policies. One can only speculate on the popular approval for

cosmonauts in a democratic Russia where its citizens are empowered to influence concrete budgetary choices, say between psychological values derived from cosmonaut activities and material values derived from some more earthy programme affecting a segment of the population.

Another example is the assumption that Russian contracts with NASA will be honoured at the specified dollar price. This assumption ignores the wrenching impacts of the transformation of an economy from an administrative to a free market pricing system. Soviet policy misrepresented the true costs to society of the military and related sectors. Russian democratic politics might well produce more honest budgets and, in so doing, inflict on the Russian NASA contractors various measures, such as higher taxes and lower social subsidies for their work force, thus increasing costs and delivery prices. This might be good news for the US launch industry. Be ready, however, to face requests for supplemental appropriations!

Domestic Policy: United States

Attention needs to be drawn to one aspect of domestic policy, derived from American psychology, with substantial budgetary implications. Social scientists may observe that safety and reliability statistics of complex systems such as the Space Shuttle are more an art than a science, and possibly coloured by the interests of their authors. The trade press includes warnings of a strong probability of another Shuttle catastrophic failure in the not distant future, possibly with loss of life, possibly during the construction phase of Space Station Alpha. Leaving aside such questions as the replacement of the payload and the possibility of its reflight on a Russian launch vehicle, how would America react to a replay of the Challenger accident, which grounded the Shuttle fleet for about three years? Should the President, Congress and NASA warn the American public of the likelihood of such an event, and resolve to deal with it on the basis of operational and technical criteria? Or shall we remain fatalistic and let the future of this joint venture be determined by the interplay of radio talk shows and press hysteria?

Foreign Policy

Space Station Alpha has been justified by the Administration in significant part on foreign policy grounds. Specifically, it is advanced that cooperation with the Russians in space activities, and especially in the Human Space Program, is highly visible, the only civilian area where both partners are equals, and the centre-piece for expanding cooperation into other areas. A secondary benefit is also seen in the non-proliferation of Russian rocket scientists to politically dangerous countries.

The Administration's foreign policy justification is based on a combination of two theories and practices of international relations. *Functionalism*, broadly defined, assumes that cooperation between two or more countries is one non-political activity will result in cooperation in other areas, including traditionally political areas. Functionalism may also be seen as one theoretical basis for the practice of *linkage*, which, as its name implies, links bilateral relations across any number of issue-areas.

This is not the place to discuss the voluminous literature of the subject, whether function drives politics or vice versa, or whether linkage drives towards an improvement or worsening of relations. But it is instructive to examine past bilateral relations from this perspective. The Soviet Union as the weaker of the two parties in all areas but defence and space, placed its hopes in the Leninist principle of the correlation of forces. According to this naive analysis of the lessons of history, achievement of nuclear parity and, to a lesser extent, achievements in space, would somehow be transformed into Soviet parity with the US in other areas, not only in international relations, but in bilateral economic relations as well. To its chagrin, this magical transformation did not take place. But otherwise, the Soviet Union honoured its bilateral treaties and agreements with the US to the letter, if not always to the spirit.

The US, in contrast, has behaved in a manner both hegemonical and unrealistic by linking a variety of bilateral agreements to its political goals. This difference in behaviour can be seen by the following example. During the Vietnam war and the period of détente, the Soviets proceeded with massive weapons assistance to North Vietnam, but also entered into a variety of agreements with the US. By contrast, when the Soviet Union invaded Afghanistan, President Carter cut off most bilateral links forged during détente, including cultural agreements, wheat exports and even US participation in the Moscow Olympic games.

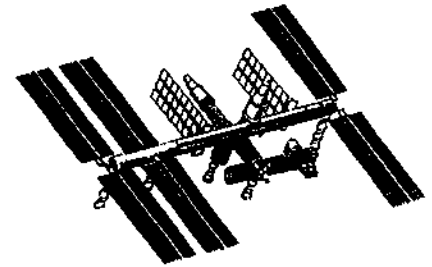
BOOK NOTICE

International Cooperation in Space: The Example of the European Space Agency

R.M. Bonnet and V. Manno, Harvard University Press, Fitzroy House, 11 Chenies Street, London, WC1E 7ET, 1995, 163pp, £29.95, ISBN 0-674-45835-4.

This book, which describes the story of the European Space Agency, describes how a major cooperative enterprise has worked for the past three decades and speculates on how this might continue to apply to future space science programmes.

ESA, which links 15 nations, provides a working model of scientific, technological



'Space Station Alpha has been justified by the Administration in significant part on foreign policy grounds.'

Past behaviour is not necessarily a guide to the future. But bureaucratic styles and reflexes change slowly. One can safely assume that national interests of the US and Russia will conflict in a number of areas. What would be the reaction of the US President, regardless of political party, when confronted not with the sale of missiles to some unsavoury country, but rather with a Russian invasion of a Baltic or Central Asian state? Would the US taxpayer's investments in Space Station Alpha be sacrificed to the perceived demands of US foreign policy? With such an eventuality in mind should the executive agreements regarding Space Station Alpha be elevated to the status of a treaty?

Recommendations

In putting forward the Institute's recommendations, it is pointed out that the public debate within the space community about the historic joint space station venture has so far been held mainly on technical and economic arguments. Risk assessments must also reflect a study of US benefits and costs derived from a relation with an unstable and unpredictable society and government. Some of these political, social, economic and diplomatic risks can be studied and analysed by social scientists, with the object of mitigating or possibly preventing some of them from happening. ■

and political cooperation on an international scale. Starting with its formation difficulties, this account traces the evolution of ESA's programmes, facilities and capabilities over the past 30 years. Its relationships with its own member states are fully described with examples of cooperation with NASA exemplified by two specific projects - Ulysses and the International Space Station Programme, both of which highlight the difficulties which arise in an association of two different decision-making bodies with their attendant political systems.

The book, in a blend of factual information and personal recollection, provides both a history and an interpretation and makes a useful contribution to the study of the politics of science and technology.



Xenon lights illuminate the Space Shuttle Atlantis at sunset on the evening before the launch of STS-66 on 3 November 1994.

ROGER G. GUILLEMETTE

Special Artwork in Orbit

Cousteau at STS-66 Launch

World-famous environmentalist Jacques-Yves Cousteau was at the Kennedy Space Center to witness the launch of Atlantis from the VIP viewing site at the special invitation of STS-66 payload specialist Scott E. Parazynski, MD and astronaut Steve Smith who was a crew member of the preceding shuttle launch, STS-68. The orbiter's payload contained some special items including one provided by Cousteau himself.

Astronaut Parazynski had asked Captain Cousteau for a special memento to carry on-board Atlantis and the 84-year French oceanographer complied by sending along one of his signature red bonnets. "Calypso's red caps are a universally recognised privilege of 'inner space' pioneers",

Smiles for the camera from Ellen Ochoa and Scott E. Parazynski as they walk with other crew members toward their specially-equipped van, about to be transported to the launch pad for the STS-66 mission.

ROGER G. GUILLEMETTE



BY ROGER G. GUILLEMETTE

Rhode Island, USA

said Cousteau, explaining that he provided the red cap "... as a symbol of humankind's dedication to discovery, progress and faith".

This was the fifth occasion that he had seen a NASA manned launch and after the spectacular lift off, he met with the media and conveyed his impressions:

"I see astronauts that come back from outer space as different people, who think more deeply into the meaning of life, what is important in life, what is the sense of happiness." These experiences he said, "lead us to realise that we are small people, ants on a beautiful planet, and that we have to take care of it."

* * *

Also manifested in Atlantis' official flight kit were four pieces of hand-painted artwork selected from those created by more than 500 special needs children and adults as part of the Very Special Arts programme. The group art project commemorated the 25th anniversary of the Apollo 11 lunar landing, as well as the 20th anniversary of the international Very Special Arts organisation.



Jacques-Yves Cousteau

Founded in 1974 by Jean Kennedy Smith, Very Special Arts provides programmes for individuals with physical and mental disabilities. Each artist created a 15 cm by 15 cm square canvas panel and these were later assembled into 4-metre square murals. One of the murals was prominently displayed in the Press Center at the Kennedy Space Center. Four of the artwork squares that were not made into murals were carried on board Atlantis and will be placed on display upon returning to Earth. One piece will be added to the permanent exhibit of the Astronaut Memorial Foundation at the John F. Kennedy Center for the Performing Arts in Washington, DC, while another piece will be exhibited at the Nautilus Foundation for Research in Tallahassee, Florida. ■

A detailed report of the STS-66 mission begins on p.100.

Janice Kershaw, an official with the Very Special Arts programme of Brevard County, Florida, poses in front of a collection of artwork in the Complex 39 Press Center at the Kennedy Space Center. The squares were painted by special needs children and adults and commemorated the 25th anniversary of the Apollo 11 mission. Four pieces of the artwork were flown aboard the Shuttle Atlantis on the STS-66 mission.

ROGER G. GUILLEMETTE



Travelling to the Stars

Eight of the nine major planets have been photographed and scrutinised by robotic craft, either by flybys or actual landings, so also have the Sun, two comets, two asteroids and countless moons. Probably the best known of such craft are Voyager 2, which explored Jupiter, Saturn, Uranus and Neptune, and Viking 1 and 2, which both landed on Mars. Although manned space missions have been restricted to near Earth orbits since the time of the Apollo programme there are plans for missions to Mars and a return to the Moon. But, apart from the cost and risks involved, travel times, physiological and other effects become apparent on journeys to Mars and beyond.

Stellar missions will involve robotic craft at first, as in the case of Mars. However, the construction of interstellar spacecraft presents a monumental task. Several designs have already been proposed, including methods of propulsion such as nuclear explosions and laser-powered propulsion.

The idea of laser propulsion for a manned mission to Epsilon Eridani, was proposed by Dr Robert L. Forward. His idea would require pushing a disc-shaped craft by a laser beam shone from a power source anchored in the Solar System. Once in the target star system, a portion of the sail would detach and move ahead of the main section to reflect the laser beam back to the main section and push it back toward Earth. The entire journey would take about 40 years to complete, the round trip to Epsilon Eridani covering 21.4 light-years. However, a robot mission could send a wealth of data, including photographs, back to Earth within 10.7 years after reaching the star system and could then proceed to yet another star system - without having to return a tired and much older human crew to Earth.

The enormous distances involved with interstellar space travel could also cause such a mission to be overtaken by technology. For instance, a much faster means of propulsion could be developed before the journey is half way through and a spacecraft could arrive at its destination many years after the completion of a second mission to the same destination.

Speeds approaching 90% that of light would produce bizarre effects, namely the phenomenon known as time dilation and the effects of such speeds on energy and mass. If a stationary observer on Earth could see the activities inside a spacecraft travelling at about 90% that of the speed of light, everything would appear in slow motion. This includes the rate of its clocks, the heartbeats of its occupants - everything. As they increase their speed, time will pass ever slower and virtually stop just below the speed of light. However, to the fast moving travellers, everything would seem normal. If an astronaut left Earth at a similar speed and returned after just a few weeks, his or her children would have been waiting so long that the returning astronaut would have become younger than they were. The extent of such differences would depend on the speed and duration of the voyage.

BY JOHN GRAYSON
Toronto, Canada

A spacecraft is prevented from actually reaching the speed of light due to the fact that the mass of the craft would increase with its speed. The energy from its source of power would start turning into mass and more energy would then be needed for further acceleration, but the craft gets harder to accelerate as more energy makes the craft more massive.

A journey to Alpha Centauri, a triple star system and our closest neighbour at 4.3 light-years, would reduce the travel time considerably for a laser powered mission compared with that proposed for Epsilon Eridani. However, there is still some controversy regarding the existence of planets in double or multiple star systems, and the study of extrasolar planets is one of the principal reasons for visiting the stars. Although the detection of such planetary systems would undoubtedly be established before a target star is chosen, the stability and nature of the planets would also be taken into consideration. Many astronomers believe that planets orbit most stars and are the norm rather than the exception, but if the nearest star with planets is no closer than 20 light-years then an interstellar journey may not take place for a long time.

Even if we could find a way to send a spacecraft to more distant stars at speeds of 50%, or more, of that of light then time dilation becomes a problem. Therefore, there is no known method of getting close-up information from distant star systems by way of interstellar spacecraft within a reasonable time frame. A spacecraft could travel from Earth to the centre of our galaxy (a distance of about 30,000 light-years) in just 21 years according to on-board time by accelerating at one Earth gravity; but no one on Earth would benefit from the experience.

Eventually, just before the Sun and Earth expire in about 4.6 billion years, our descendants will have to leave for ever, unless a method for prolonging

About the Author



John Grayson Jr.

John Grayson was born in Bristol, England and lived in Nigeria for a number of years. He completed his schooling in the UK and Canada where he has lived since the end of 1968.

He has had two books published, the first is entitled *Light-Years* and is an account of the universe for a lay audience. His second, *Extraterrestrial Life*, is a scientific view also aimed at a lay audience. It is available throughout Canada, parts of the US, Cuba and soon in various locations in Central America. It will also be translated into Spanish. In the not too distant future, it should also be on sale in the UK.

the Sun's evolution is found. However long before this, travellers from Earth would most probably have embarked on one way journeys anyway. Some may find suitable planets on which to settle and some may sail through the universe indefinitely, surviving in giant self-sufficient spaceship colonies similar to the O'Neill cylinders proposed by Gerard K. O'Neill in 1974. These cylinders would rotate slowly so that centrifugal force creates an artificial effect of gravity on the inside hull. The inside surface could accommodate lakes, rivers, forests, farms, factories and millions of occupants. Two, or more cylinders could be joined, rotating in opposite directions to maintain stability. They would be artificial planets and their occupants may live their entire lives without ever setting foot on a natural planet.

A mass exodus, leaving in different directions, would mean that evolution will eventually create a variety of different species that may someday bear little resemblance to mankind of today. Therefore, unless we suffer a disastrous setback, mankind will eventually journey towards the stars. ■

One-page 'INTO SPACE' articles offer readers the opportunity to express their ideas and 'think aloud' on topics which they see as important and of interest to others. Contributions of an appropriate (one-page) length may be sent to the editor at any time and should be accompanied with a photo of the writer (head and shoulders) and a few lines of personal details.

"Looking Inside" Stars

Minute Temperature Fluctuations
Detected in η Boötis

Astronomers from the Aarhus University (Denmark) and the European Southern Observatory have for the first time detected solar-type oscillations in a star. They observed the temperature of the bright northern star η Boötis during six nights with the 2.5 metre Nordic Optical Telescope at the Roque de los Muchachos observatory on the island of La Palma (Canary Islands) and were able to show that it varies periodically by a few hundredths of a degree.

These changes are caused by pressure waves in the star and are directly dependent on its inner structure. A detailed analysis by the astronomers has shown that the observed effects are in good agreement with current stellar models and are a most important, independent test of stellar theory.

The Sun Oscillates

About twenty years ago, it was discovered that the Sun oscillates like the ringing of a bell with a period of about 5 minutes. The same phenomenon is known in the Earth, which begins to vibrate after earthquakes; and seismologists have been able to discern a layered structure in the Earth's interior. The recent impacts of a comet on Jupiter most likely had a similar effect on that planet.

The observed solar oscillations concern the entire gaseous body of the Sun, but we can of course only observe them on its surface. It has been found that each mode moves the surface up and down by less than 25 metres and that the combined motion is very complicated, because there are many different, simultaneous modes, each of which has a slightly different period. The exact values of these periods are sensitive to the speed of sound in the Sun's interior, which in turn depends on the density of the material there. Thus, by measuring the periods of solar oscillations, we may probe the internal structure of the Sun, that is otherwise inaccessible to observation.

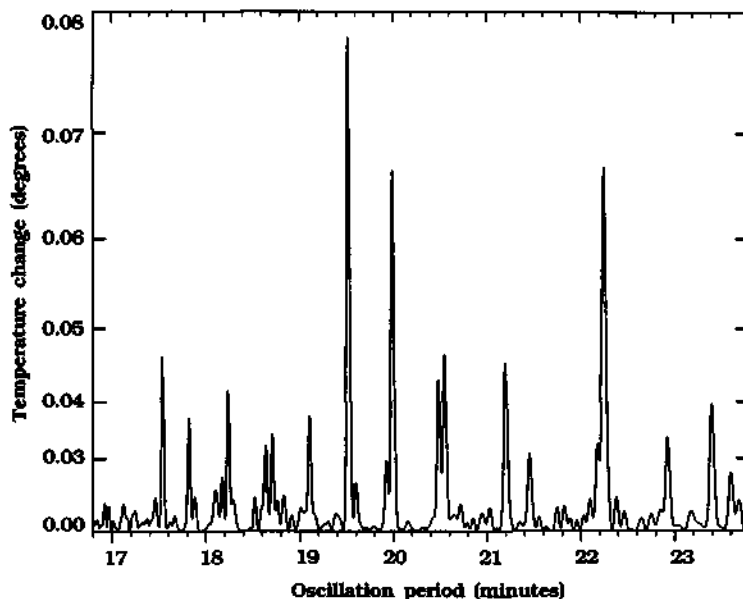
Why does the Sun oscillate and what is the cause of these oscillations? We do not know yet, but it is thought that the driving force is convective motion in the interior. For a better understanding of this basic phenomenon, we may compare the Sun with a pot of boiling water on the stove. The "bubbles" in the pot, known as *solar convection cells*, rise upwards towards the surface and jostle the Sun from the inside. This causes it to oscillate, although we still do not know the details of how these oscillations are triggered. We can just be grateful they exist, and by measuring their periods we obtain important information about the inside of the Sun. A great deal of progress has recently been made in this way.

Do Other Stars Oscillate?

The Sun is a normal star. It oscillates, and we would therefore expect that other,

similar stars also do.

Indeed, large-amplitude stellar oscillations have been known for centuries to manifest themselves as significant changes in the observed brightness of some "variable stars". However, in most cases, for example in the so-called Cepheid and RR Lyrae variable stars, only



Oscillations observed in η Boötis in the form of a power spectrum of temperature change.

one or two periods have been detected. What distinguishes solar-type oscillations is their much smaller amplitudes and the large number of observed periods, that potentially gives a great deal of information about a stellar interior.

During the past decade, astronomers have been trying to detect this type of oscillation in stars other than the Sun, but with little success. Such oscillations are much more difficult to detect, because the stars are much further away and therefore fainter than the Sun.

Most observational attempts have tried to detect the movement of the stellar surface directly, by measuring velocity (Doppler) shifts in the stellar spectra. Up-down motions of less than 1 m/sec shift spectral lines backwards and forwards by about 1 part in 300,000,000 or less than 0.00002 nm in red light, a minuscule shift that is very difficult to measure with current astronomical instrumentation, even in the very brightest stars.

Faced with this problem, the Danish/ESO group came up with an entirely new method. It relies on the fact that the oscillations are sound waves which deposit energy in the various stellar layers and therefore intermittently heat the star very slightly. For example, each mode changes the temperature on the surface of the Sun by about 0.005 degrees during the oscillation.

But how to measure such small temperature changes? It turns out that this is possible by recording the strengths of the spectral lines, specifically, the absorption lines due to hydrogen. Their strengths change slightly with the changes in temperature. Although this is still a very small effect, it should be easier to measure than the velocity shifts.

Yes, η Boötis Does!

The 2.68 magnitude, naked-eye star η Boötis was selected for observation. This particular star is somewhat more evolved and bigger than the Sun and, according to stellar theory, should have stronger oscillations than the Sun, hence increasing the chance of detecting them.

The observations were performed with the 2.5 metre Nordic Optical Telescope during six, mostly clear nights in April 1994. Careful data analysis has now shown that the temperature of η Boötis is indeed changing periodically, around a mean value of ~ 6000 K. It seems to be oscillating in at least ten different modes simultaneously, with periods around 20 minutes. These periods are longer than those of the Sun, as expected for a star that is larger and heavier than the Sun.

The figure shows these oscillations in the form of a "power spectrum", i.e. the amount of temperature change at different values of the period. Most of the highest peaks correspond to real oscillations in the star. The amplitudes of the temperature changes of η

Boötis vary with the oscillation mode and, at the time of these observations, were mostly between 0.03 and 0.08 degrees.

Agreement with Theory

Theoretical models of η Boötis have now been compared with these observations and the astronomers were pleased to find that the agreement is excellent, implying that current stellar theory is remarkably good. Future observations of this kind, with ground based telescopes and possibly also from space, promise to open up a new and exciting way of studying stars. From now on, we will be able "to look inside" stars in greater detail. ■

The astronomers involved in this work are Hans Kjeldsen, Michael Viskum and Søren Frandsen (IFA), Jørgen Christensen-Dalsgaard (IFA), and Theoretical Astrophysics Center, Danish National Research Foundation, and Tim Bedding (ESA). Hans Kjeldsen was supported by a grant from the Carlsberg Foundation.

Astronomy Teachers Unite

European Association for Astronomy Education Formed

A joint European Union/European Southern Observatory (EU/ESO) Workshop on Teaching of Astronomy in Europe was held at ESO Headquarters in Garching, near Munich, from 25-30 November 1994 under the auspices of the 1994 European Week for Scientific Culture. More than 100 teachers from secondary schools in 17 European countries and others participated.

Summary

The meeting was the first of its kind ever held and agreed to form the *European Association for Astronomy Education (EAAE)*, uniting astronomy educators all over Europe into one network. A provisional Executive Committee of the EAAE was elected which will work towards the organisation of a constitutional conference within the next year.

The participants unanimously adopted a four-page Declaration on the Teaching of Astronomy in Europe, specifying the overall aims and initial actions needed to achieve them.

Astronomy: Science, Technology and Culture

Lectures were given about some of the most active fields of astronomy. The scientific sessions included topics as diverse as minor bodies in the solar system, nucleosynthesis, interstellar chemistry and cosmology.

Overviews of various recent advances in astronomical technology followed, some of which are already having a direct impact on highly specialised sectors of European industry. They include the advanced use of computers in astronomy, for instance for image processing and data archiving, as well as remote observing which was demonstrated.

Discussing the cultural aspects of astronomy, Nigel Calder (UK) and Hubert Reeves (France) emphasised its important role in modern society, in particular its continuing influence on our perceptions of mankind's unique location in time and space.

Teaching of Astronomy in European Countries

Representatives of individual countries presented the current status of astronomy teaching in their respective areas. This was the first time such an exchange of information has ever taken place at a European level, and there are clearly many different approaches to the teaching of astronomy, which is rarely presented in a global and coherent way. Most often, disparate elements of astronomy are incorporated into other subjects, e.g., geography, mathematics, physics, chemistry, the geo-sciences, history and philosophy.

Only a few countries have so far established well balanced astronomy courses at the secondary level of education. In some, students may pass

through school and only be exposed to the most rudimentary astronomical terms, or even none at all.

These presentations demonstrated that now is probably an ideal moment to consider how astronomy may best be incorporated.

The 'Declaration'

The Declaration emphasized the need to establish an international network which will provide an efficient basis for future cooperation. In-service education of teachers is still lacking in many places and many teachers are

unfamiliar with the more recent advances in astronomy. Many are unaware of the associated educational materials now available and of the wide spectrum of extra-curricular student activities that are possible in connection with astronomy.

At the end of the Workshop, the participants by unanimous decision resolved to set up the *European Association for Astronomy Education* which from now on will form the Europe-wide network for this subject and unit all European astronomy teachers. ■

About Galaxy Formation



A Hubble Space Telescope image of the central portion of a remote cluster of galaxies (CL 0939 + 4713) as it looked when the universe was two-thirds of its present age. The picture confirms that billions of years ago, clusters of galaxies contained not only the types of galaxies dominating their descendant clusters today, but also several times as many spiral galaxies. These spiral galaxies have since disappeared through mergers and disruptions.

ALAN DRESSLER (CARNEGIE INSTITUTION) and NASA

Although astronomers have uncovered many of the details revealing the life cycles of individual stars, they still do not completely understand how galaxies, like our Milky Way, begin and end their lives.

The problem is that, although stars within the Milky Way may be seen in a variety of evolutionary stages, few examples of young galaxies are known, and their images come to us from the most distant edge of the visible universe. At these vast, multi-billion-light-years distances, it becomes increasingly difficult to determine what role environment plays in the formation of a galaxy.

Theoretical investigations indicate that galaxies formed from a diluted but lumpy mixture of hydrogen and helium gas - the primordial elements forged in the Big Bang. They also indicate that two vastly different scales of mass prevailed less than 100 million years after the Big Bang, which ultimately affected the formation of galaxies.

Matter was either clumped into vast collections more than a million times the mass of the Milky Way or into small clumps one million times smaller than the mass of the Milky Way.

Superclusters of galaxies may have evolved from the former. Globular clusters - spherical collections of very old, densely packed stars usually found in orbit around galaxies, like the Milky Way - may have evolved from the latter.

Could these globular clusters be the meagre leftovers of an ancient, once-common population of small clumps as predicted by theory? This possibility now seems increasingly more likely. So the question then arises: what formed the vast majority of the galaxies?

Detailed ground-based and space-based images of distant galaxies are beginning to turn up some interesting insights into galaxy formation.

First, as we look deeper into the universe, galaxies appear to emit more of their light in the blue part of the visible spectrum. From studies of nearby galaxies, blue light is a sign that very young, massive and luminous stars are forming. Since we see these galaxies as they were between 5 and 10 billion years ago, we appear to be witnessing events that occurred within a few billions of years after these galaxies were formed.

Based on NASA *Space Science Short*, December 1994.



Hubble's view of the Cartwheel Galaxy.

KIRK BORNE (STScI) and NASA

Galaxies Collide Aftermath Observed

Hubble Reveals 'Ring World' of Newborn Stars

Located at a distance of 500 million light-years the Cartwheel Galaxy is one of two galaxies that have been involved in a rare and spectacular head-on collision. The above Hubble true colour image provides an opportunity to study how extremely massive stars are born in the large fragmented gas clouds produced by such a collision.

The striking ring-like feature that surrounds the galaxy on the left is a direct result of a smaller intruder galaxy - possibly one of the two objects to the right - that careered through the core of the ring's host galaxy. The energy of the collision then rippled outwards into space, ploughing gas and dust in front of it. Expanding at 200,000 miles per hour, this cosmic wave generates the conditions for new star creation. Hubble resolves bright blue knots that are gigantic clusters of newborn stars and immense loops and bubbles blown into space by supernovae exploding like a string of firecrackers.

Before the collision the Cartwheel Galaxy was presumably a normal spiral galaxy like our Milky Way. Its spiral structure is beginning to re-emerge in the faint arms that extend out to the ring, which contains at least several billion new stars that would not normally have been created in such a short time span. It is so large (150,000 light-years across) that the entire Milky Way would fit inside.

Which of the two small galaxies might have been the intruder is not certain. The blue one is disrupted and

has new star formation which strongly suggests that it was the intruder. However, the smoother-looking one has no gas, which is consistent with the idea that gas was stripped out of it during passage through the Cartwheel Galaxy.

Hubble shows the knot-like structure of the ring, produced by large clusters of new star formation. The Hubble image also resolves the effects of thousands of supernovae on the ring structure. One flurry of explosions blew a hole in the ring and formed a giant 'bubble' of hot gas. Hubble resolves remarkable new detail in the galaxy's core. The colour of this region indicates that it contains a tremendous amount of dust and embedded star formation. Bright pinpoints of light are found which are gigantic young star clusters.

The picture was taken on 16 October 1994, with the Wide Field Planetary Camera-2 and is a combination of two images, taken in blue and near-infrared light.

The Hubble Space Telescope is a project of international cooperation between NASA and ESA (the European Space Agency).

Small Star Found

Hubble Images Start Study of Smallest Stars

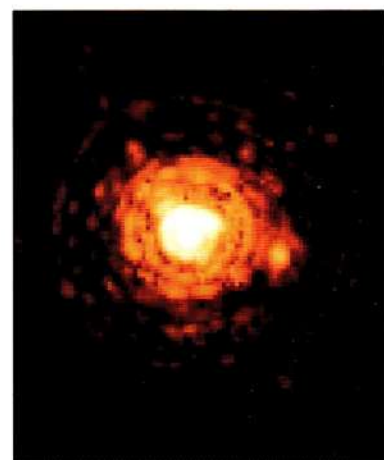
Located 25 light years away, in the constellation Hercules, Gl623b is the smaller component of a double star system, where the separation between the two members is only twice the distance between Earth and the Sun. The small star completes one orbit about its larger companion every four years.

Gl623b was first detected, indirectly, from previous astrometric observations that measured the wobble of the primary star due to the gravitational pull of its smaller, invisible companion. However the star is too dim and too close to its companion star to be seen by ground-based telescopes, but Hubble's view is sharp enough to separate the two.

In the picture below taken by the European Space Agency's faint object camera on board the Hubble Space Telescope, Gl623b is the diminutive star (right of centre) and is ten times less massive than the Sun and 60,000 times fainter. The new Hubble observations will allow the intrinsic brightness and mass of Gl623b to be measured and this in turn will lead to a better understanding of the formation and evolution of the smallest stars currently known. Red dwarf stars were until recently thought to be the most abundant stars in the Galaxy, constituting the invisible matter, called 'dark matter', which was believed to account for more than 90 per cent of the mass of the universe. However, previous Hubble observations published in November 1994 showed these low mass stars to be surprisingly rare.

The image of Gliese 623b (or Gl623b) taken in visible light on 11 June 1994 with the ESA Faint Object Camera.

C. BARBIERI (UNIV. OF PADUA) and NASA/ESA



The investigators in this work were Cesare Barbieri, Gabriele Corrain, Roberto Ragazzoni (Univ. of Padua), Antonella Nota, Guido De Marchi and Duccio Macchetto (ESA/STScI), and the FOC Instrument Definition Team.

Saturn

Mystery Summertime Storm

This Hubble Space Telescope image of Saturn taken with Wide Field Planetary Camera 2 on 1 December 1994 shows a rare storm that appears as a white arrowhead-shaped feature near the planet's equator.

The storm is generated by an upwelling of warmer air, similar to a terrestrial thunderhead. The east-west extent of this storm is equal to the diameter of the Earth. The storm's motion and size have changed little since its discovery in September 1994.

On the left side of the bright central cloud, Saturn's prevailing winds shape a dark "wedge". At the latitude of the wedge are the planet's strongest eastward winds (clocked at 1,000 miles per hour from analysis of Voyager spacecraft images taken in 1980-81).

The storm's white clouds are ammonia ice crystals that form when an upward flow of warmer gases meets Saturn's very cold cloud tops. Hubble



Saturn imaged by Hubble at a distance of 904 million miles. The picture is actually a composite of images taken through different colour filters within a six-minute interval in order to create a 'true-colour' rendition of the planet.

RETA BEEBE (NEW MEXICO STATE UNIVERSITY), D. GILMORE, L. BERGERON (STScI) and NASA

observed a similar, though larger, storm in September 1990, which was one of the three major Saturn storms seen over the past two centuries. Although these events were separated

by about 57 years (approximately 2 Saturnian years) there is yet no explanation why they apparently follow a cycle - occurring when it is summer in Saturn's northern hemisphere.

Close Cluster Pair Give Evolutionary Clue

Hubble's high-quality images have extended detailed studies of stellar populations one hundred times farther into the universe, out to the distance of a neighbouring galaxy, thereby overcoming the previous restriction to nearby star-forming regions within the plane of the Milky Way.

Attention has centred on two clusters that are unusually close together for such distinct and separate objects. The pair are 166,000 light-years away in the Large Magellanic Cloud (LMC) in the southern constellation *Doradus*.

N. Panagia and R. Gilmozzi of the Space Telescope Science Institute (STScI) in Baltimore, Maryland and the European Space Agency (ESA) and co-investigators have identified three separate populations in this concentration of nearly 10,000 stars. About 60 percent of the stars belong to the dense cluster called NGC 1850, which is estimated to be 50 million years old.

A loose distribution of extremely hot massive stars in the same region are only about 4 million years old and represent about 20 per cent of the stars in the image. (The remainder are field stars in the LMC.) The significant difference between the two cluster ages suggests that they are two separate star groups that lie along the same line of sight. It is probably the younger, more open cluster that lies behind the older cluster (by 200 light-years) otherwise if it were in the foreground, dust in the younger cluster would obscure stars in the older cluster.

Having two well-defined star popula-

tions separated by such a small gap is unusual and suggests an evolutionary interpretation. A possible scenario is that an expanding "bubble" of hot gas, from more than 1,000 supernova explosions in the older cluster, might have triggered the birth of the younger cluster. This would have happened when the bubble had been expanding for 45 million years before ploughing into a wall of cool gas and dust, causing the gas to contract and precipitate a new generation of star formation. The massive, hot stars so formed would be destined to explode in a few million years and thus create yet another expanding bubble of gas.

These findings were due to be published in the 1 November 1994 issue of the *Astrophysical Journal Letters*.

The colour composite image below is assembled from exposures taken in UV, visible and near-IR light. The many yellow stars correspond to Main Sequence stars (like the Sun) with average surface temperatures of 6000 K; red stars are cool giants and supergiants (3500 K); and white stars are hot young stars (25,000 K or more) that are bright in UV. It is suggested that supernova explosions in the older yellow cluster might have triggered the birth of the younger cluster.

R. GILMOZZI, STScI/ESA; SHAWN EWALD, JPL; and NASA



New Camera for Hubble

HACE (Hubble Advanced Camera for Exploration) is the name of a new camera that NASA has decided to develop for the Hubble Space Telescope. It will cost about \$30 million and its hardware will be built by Ball Aerospace in Boulder, Colorado.

HACE is planned for installation into the orbiting observatory's instrument bay by space shuttle astronauts during the third servicing mission scheduled for November 1999. One of the current instruments aboard Hubble will have to be taken out to make room for the new camera and which one will be decided two or three years before the mission. HACE's capabilities will be a major enhancement to the HST's present camera, the Wide Field Planetary Camera-2 which was installed during the servicing mission of December 1993.

"Through the Eyes of Hubble"

Planetarium visitors around the world will have an opportunity to explore black holes, embryonic solar systems, primeval galaxies and other wonders of the universe as revealed by NASA's Hubble Space Telescope in a planetarium program entitled "Through the Eyes of Hubble".

Through computer graphics, multi-screened video projections, and dozens of special effect projectors the new program presents a celestial array of spectacular Hubble results including observations of Comet Shoemaker-Levy 9's crash into Jupiter, protoplanetary systems in the Orion Nebula, monstrous black holes, infant galaxies, and other observations that may shed light on the fate of the cosmos itself.

"Hubble's results are revolutionising astronomy, and we are eager to share the intrigue and excitement of these discoveries with planetarium visitors worldwide", says Dr Robert Williams, Director of the Space Telescope Science Institute. "Our mission to educate the public about astronomical discovery is no less important than our operating the Hubble Space Telescope".

The 40-minute multimedia show is a joint production of the Space Telescope Science Institute, Baltimore,

MD, and Henry Buyhl, Jr Planetarium and Observatory, Pittsburgh, PA. Following its 17 March 1995 debut at the Carnegie Science Center in Pittsburgh, the show will be sold internationally to other planetariums. "This joint project between the professional astronomers and The Carnegie Science Center's planetarium staff will take the public out to the edge of our knowledge about the universe", says Seddon Bennington, director of The Carnegie Science Center.

Actress Gates McFadden, who plays Dr Beverly Crusher in the television series *Star Trek The Next Generation* narrates the show. "For the last seven years I've had the opportunity to bring fictional space exploration into many lives in my role on *Star Trek*", she says. "Now, this is a wonderful opportunity to share in the real exploration of space. Though we can't yet travel to the stars, Hubble is boldly looking where no one has looked before".

Sun's Magnetic Field

The strength of the Sun's magnetic field appears uniform, whether at the equator or the poles.

This finding which appears in data from Ulysses' flyby of the Sun's south pole (*Spaceflight*, December 1994, p.417) contradicts conventional thought, namely that the Sun's magnetic field is strongest at the poles, just like that of the Earth. Somewhere in the Sun's corona, the magnetic field appears to be redistributed from its original dipolar shape. During its passage of the polar region, Ulysses remained more than twice as far from the Sun as the Earth itself.

NEAR Mission to Eros

The first comprehensive measurements of an asteroid's mass, structure, geology, mineral composition, gravity field and magnetic field is the goal of the NEAR (Near Earth Asteroid Rendezvous) project of NASA. A spacecraft scheduled for launch in February 1996 should arrive in orbit around asteroid 433 Eros in early January 1999. It will then survey the rocky body for a minimum of one year at altitudes as close as 24 km. On 21 September 1994, NASA selected the members of the NEAR Science team.

'Interstellar Probes' Competition

Interstellar flight by manned vehicles is still a vision of the future. But this is not the case for unmanned vehicles as four NASA spacecraft launched in the 1970s to the outer planets have now departed the known Solar System. This month's competition puts the spotlight on the four spacecraft concerned - and offers readers an opportunity to win a prize.

Prizes: The first four correct entries to be opened after the closing date of 6 April 1995 will receive a copy of the video:

A Collection of the "Movies"

(This video features four short productions which use satellite/space probe images and supercomputer graphic animation.)

To Enter: Supply answers to the following questions:

1. Which two space probes carry a plaque to serve as a form of communication with any intelligent species that might come across them in a future millennium:

2. Which two space probes carry a message from the former US President Jimmy Carter containing the words '....this record represents our hope and our determination, and our good will in a vast and awesome universe.':

3. Put the names of these four space probes in the chronological order of their date of launch:

4. Put their names in order of their present distances from the inner Solar System beginning with the most distant:

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 6 April 1995.

* Tapes are VHS PAL format only and are not compatible with the US NTSC system.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name

Address

The Evening Star: Venus Observed

H.S.F. Cooper Jr, The Johns Hopkins University Press, 2715 N Charles Street, Baltimore, MD 21218-4319, USA, 1994, 300pp, £10.50, ISBN 0-8018-4934-9.

This book contains a summary of our knowledge about Venus, based on information gleaned from the series of space probes to the planet which culminated in the triumph of Magellan.

Much of its account is taken up with the flight of Magellan itself, including many comments culled at first hand to describe Magellan's trials and tribulations and the final successful outcome, providing the dramatic extension of our knowledge of the planet which took place as a result of this flight.

This adds up to a gripping story written almost in the vein of a semi-history.

The Cambridge Atlas of Astronomy

J. Audouze, G. Israel and J.C. Falque, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1994 471pp, £50, ISBN 0-521-43438-6.

The third edition of this first-rate atlas, an English edition of which first appeared in 1985, provides a comprehensive guide to planetary science, astronomy and astrophysics. It has been expanded by a further 40 pages to take account of recent developments and continues the practice of using numerous illustrations, averaging about two or three on each page, to accompany an informative text and tables.

A total of 130 articles have been contributed by a team of professional astronomers based in France, arranged systematically, by topic, commencing with the Sun and Solar System and moving outwards to the Stars, Galaxies, the Universe and Cosmology generally.

Substantial changes have occurred in the section on the Solar System. The text on Venus has been updated to include the Magellan Mission and entirely new sections have been added on Neptune, Pluto and Solar System debris. Recent developments in Astrophysics have also led to extensive revisions of the text relating to topics such as Black Holes, Collapsed Stars, Active Galaxies, etc.

Reference data include star maps which show the location of the brightest stars in the Northern Hemisphere and there are some 50 tables of data and a detailed Glossary and Index to enable any fact to be found quickly.

Astronomy Selection

The Observer's Guide to Astronomy, Vols 1 & 2

Ed. P. Martinez, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, Vol 1, 1994, 594pp, £50, ISBN 0-521-37945-8. Vol 2, 1994, 553pp, £50, ISBN 0-521-45898-6.

These two volumes, together, constitute amazingly good observational guides for the serious amateur astronomer. Topics in Volume 1 range from spectroscopy of the Sun and photoelectric photometry of comets to tracking artificial satellites and predicting their re-entry and breakup. Sound practical methods of observation, as well as the scientific background, are described for each topic to enable the reader to make valuable observations. Guidelines included show how to record and catalogue observations, using the recognised professional terminology and classification schemes.

The guide is packed with practical tips for all types of amateur observation, ranging from simple pencil drawings of the Moon to photoelectric photometry of rotating minor planets. It will encourage the keen novice to develop his skills and will also undoubtedly satisfy the more demanding needs of an experienced amateur astronomer.

Topics in Volume 2 range from the spectroscopy of meteors to visual and photographic observations of the aurora, double stars and deep sky objects. Once again, the range catered for starts with such matters as simple visual observations of variable stars and goes on to observing the most distant galaxies with state-of-the-art CCD cameras and photoelectric photometers.

An Introduction to Cosmochemistry

C.R. Cowley, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1995, 490pp, £50.00 Hardback, £19.95 Paperback, ISBN 0-521-41538-1.

Cosmochemistry is really a further extension of the better-known scientific discipline of geochemistry. It embraces four main branches of physical science viz astronomy, geology, chemistry and physics.

The theme of this volume is the composition and evolution of material objects in the Universe i.e. the origin of the chemical elements and their subsequent his-

tory. It shows how relative abundances reveal the nuclear and chemical processes which brought them into being, in diverse topics which cover virtually everything from terrestrial and Moon rocks to distant galaxies and quasars. The volume includes a resume of the necessary tools available from chemistry, mineralogy and physics and features illustrative problems and an extensive bibliography, both aimed at the advanced student.

The book endeavours to present a broad canvas describing the chemical and nuclear history of matter as it is understood today. The first need is to determine the chemical composition of matter in the material universe: the second is to understand the reasons for the compositions that are found. The first, basically, is a matter of analytical chemistry but the second involves important evolutionary aspects.

The Great Astronomical Revolution: 1534-1687 and the Space Age Epilogue

P. Moore, Albion publishing Ltd., Coll House, Westergate Street, Aldingbourne, Chichester, West Sussex, PO20 6QL, 1994, 258pp, £17.50 Hardback, £9.95 Paperback, ISBN 1-898563-19-5.

A major scientific revolution began in 1534 when Copernicus cast aside the ancient Greek ideas and argued that the planets revolved around the Sun. His work was followed by that of Tycho Brahe who, between 1576 and 1596, made the astronomical observations which then enabled Kepler to formulate his laws of motion and to prove that the Earth, indeed, travelled in an elliptical orbit around the Sun. Soon afterwards came the invention of the telescope and the observations of Galileo, the period covered by this book ending finally with the work of Newton who developed the mathematical proof of how bodies move in space.

This is an epic and fascinating story about a great area of scientific history and which can be read with pleasure by almost everyone interested in the subject. To round things off, the author has jumped a further three centuries in order to describe the second new astronomical revolution which has taken place in our time and which would never have happened without

the work of such early pioneers. Few will doubt, also, the view of the author that these two revolutions in astronomy will be followed by a third, providing a deluge of new astronomical discoveries which will give an enormous enhancement to our knowledge of the Universe.

Chasing the Shadow

J. Harris and R. Talcott, Kalmbach Publishing Co, 21027 Crossroads Circle PO Box 1612, Waukesha, WI 53187, USA, 160pp, 1994, \$18.95, ISBN 0-913135-21-6.

In ancient times people fled solar eclipses or regarded them with foreboding. Today, would-be viewers flock to the best observing sites and often travel halfway round the world to get the best view.

A total solar eclipse is a unique phenomenon and an experience not to be missed. For those unwilling to travel far, the next one visible in the UK will be best seen from Cornwall in August 1999, and one hears that accommodation there is being booked already.

This softcover book is a mine of information about eclipses through to the year 2020. It says where they can be seen and the best places for viewing them, gives maps showing their tracks and the stars that will be visible at the time, cloud permitting. It also adds much other useful information, including climate and weather notes, tips and hints on viewing and photography.

The Astronomer's Sourcebook

B. Gibson, Gazelle Book Services Ltd., Falcon House, queen Square, Lancaster, LA1 1RN, 1992, 302pp, £17.50, ISBN 0-933149-43-3.

This is a really easy-to-read reference book which takes each aspect of astronomy in turn and provides a directory of where further information can be obtained. The first chapter, for example, on "Armchair Astronomy" includes such topics as books, periodicals, hot-lines and even details of gifts and novelties. The following section is on organisations (restricted to American) with following chapters embracing the techniques of buying telescopes and accessories and utilising them to best advantage.

A miscellany of subsequent chapters include some details of US space-based astronomy projects, a thumb-nail history of astronomy and a description of facilities available in the US for the study of astronomy.

The book is rounded off by a series of straightforward appendices.

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.



Readers Write

Millennium Telescope

Sir, Courtesy of the *Daily Telegraph*, a good opportunity to advocate space and astronomy in Britain may arise in the next few years. In September 1994, the newspaper's science editor, Roger Highfield, requested readers' proposals for projects to celebrate British Science, which would be funded out of the Millennium Fund to be raised by the National Lottery by about the turn of the Century. The top 10 proposals would attract a modest prize. Rather to my surprise, I was informed in November that my proposal had been well received and that I had won a quarter share of the top prize of £100.

My proposal is that an amateur class 8" SCT telescope, plus CCD equipment, be launched aboard a small satellite bus (of 200-300 kg or so) and used to feed astronomical images "live from Space" to a science-dedicated TV Channel or programme, perhaps to schools or the Open University, or even simply to an "Horizon" type programme on a regular basis.

Such a project would:

- Introduce the nation's public and especially our children to the beauties as well as the science of the Universe directly in their own living rooms thereby bypassing Britain's cold, cloudy and generally light-polluted skies.
- Celebrate the long-established tradition of the amateur contribution to British science in general and astronomy in particular.
- If actually taken up by the funding committee in early 1995 it may gain some publicity, which I would naturally like to see used to promote the message of building a Human(e) future in Space.

As of now, my proposal has been passed to Professor Sweeting of Surrey University for detailed consideration of its technical feasibility.

MICHAEL MARTIN-SMITH,
BSc, MRCGP, FBIS
Hull, UK

Space Record

Sir, It has been a long year on Earth, but imagine spending it in orbit! Russian cosmonaut Valeriy Polyakov, MD, has done just that and breaks the old single-mission endurance record set by Titov and Manarov in December 1988. That was 365d 22h 39m.

Polyakov was launched on Soyuz TM-18 on 8 January 1994 at 10:05 GMT. So he matched the old record on 9 January 1995 at 08:44 GMT.

With his previous mission aboard Mir, he broke the previous career total space flight experience record held by Musa Manarov months ago. Dr Polyakov is really the "Tsar of Outer Space" now!

To set a new record officially, he needs to exceed the old record by 10%, or fly for an additional 36d 14h 16m. If he does - there is no reason why he should not be

able to - he will set a new world duration record of 402d 12h 57m on 14 February 1995 at 23:00 GMT. And he will set new records every day through to the nominal end of mission or 26 March, about 441 days in all.

Since he is occupying the "third seat", or researcher-cosmonaut, position on Mir, and the US and ESA will be leasing that crew position through to 1997, there is no chance of anyone exceeding Polyakov's record on Mir. As to doing so on ISSA (International Space Station Alpha), that is a task for the next century. Any Volunteers?

So best wishes to Dr Polyakov, and happy landings!

JAMES OBERG
Texas, USA

Extraterrestrial Artefact?

Sir, A white bolide of -7m flew over the Kursk, Belgorod and Kharkov regions from north to south at 17:45 UT on 15 May 1994 [1-5]. The bolide's trajectory was about 300 km in length. It was observed by many people including five staff astronomers of the Kharkov University Astronomical Observatory, who reported a flight time of about 10 seconds. Hence the bolide's velocity was about 30 km/s.

The impact site was found to be 40 km to the SSW from Kharkov, near the village of Okhoochee, in accordance with a report by the bolide's observers. Dr Vladimir A. Zakhzhaj (director of the Kharkov University Astronomical Observatory) visited the site with an official expedition from the observatory on 27 May 1994:

"On the edge of forest we saw a crater of 4m diameter and 1.5m depth, obviously from the explosion, the energy of which was estimated to be equal to at least 60 kg of trotyl. We found about 10 kg of metallic substance within a radius of 40-50 m from the explosion centre. The forest was felled within a radius of 10 m, and burnt trees were hit by debris. Two trees were mostly burnt in the northern direction from the crater - the most probable flight direction. Preliminary chemical analysis of one sample shows an anomalous composition: the iron abundance being obviously higher than in cases of debris of any cosmic device. It is necessary to study the samples found and the impact site further." [5].

I myself saw the debris, the largest piece being a crumpled and exploded tube of 50 cm length and 2-3 cm thickness with shallow thread furrows on its surface. Its chemical composition was Fe-99%; Cu - 0.3%; Ni - 0.04%; Ti - 0.02%; (Mg and Al were not found [2,3]) and seemed more appropriate to a heavy tank than a lighter artificial satellite. Members of the expedition told me that the explosion was not due to an old World War II weapon. I saw ablation furrows and scale (black crust) on the surface of debris. Dr V.A. Zakhzhaj has consulted military experts but did not meet with any success.

Apparently this artefact of unknown origin seems a promising candidate for being extraterrestrial trash which accidentally hit the Earth. At least that possibility

must be taken into account.

A.V. ARKHIPOV
Institute of Radio Astronomy,
Kharkov, Ukraine

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1. A.V. Arkhipov, "What fell down near Kharkov?", *Vechernij Kharkov*, No. 72 (7227) p.6, 25 June 1994 (in Russian).
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3. A.V. Arkhipov, correspondence, *Zemlya i Vselennaya*, No. 1, 1995 (in Russian).
4. V. Matveev, Official answer of the Kursk's Staff on Civilian Defence, Extraordinary Incidents and Liquidation of Consequences of Natural Disasters, Letter No. 464, August 25, 1994 (In Russian).
5. V.A. Zakhzhaj, "Kharkov's bolide", *Kharkovskij kurier*, No. 53 (154), p.16, 15 July 1994 (in Russian).

Solar Sail Stability

Sir, In the article "Solar Sails and Kites" (*Spaceflight*, November 1994) the author states that a spinning disk is unstable because any rotating object prefers to spin about an axis which minimises its moment of inertia. This is not true. A disk is stable because any rotating object in free-fall prefers to spin about an axis which maximises its moment of inertia (call it I). The point is that angular momentum (call it L) is conserved, while energy (which is $\frac{1}{2} L^2/I$) is minimised by dissipation. Hence I is maximised. A complete derivation would require matrices, but the conclusion is the same.

The familiar example is of flexible wire attached to a drill chuck. This is deceptive, since angular velocity, not angular momentum, is held constant by the drill mechanism.

By the way, while a disk itself is stable, a disk-plus-payload configuration is something else entirely.

SCOTT OSBORNE
University of Washington, USA

The author, Colin Jack, writes: The full picture is that a rigid body can spin stably about an axis which either maximises or minimises its moment of inertia, but not in an intermediate direction. Which of these 'preferred' axes is chosen depends on the initial conditions. This rather surprising behaviour can be verified with an oblong object such as a matchbox. Tossed into the air spinning about the longest or shortest of its three axes, it spins stably; spun about the width axis, it tumbles. For a formal explanation see T.W. Kibble, *Classical Mechanics* (2nd ed.), Chapter 11.

Unfortunately a disk sail is not a fully rigid body. In particular, when spinning about its principal axis, there is essentially no damping force to prevent portions of the fabric penduluming in the direction parallel to the axis. While the potential motions are too complex for classical mechanics to model, the consensus appears to be that stability in this position cannot be relied upon. Louis Friedman, former director of JPL's major solar sail study, lists both the circular and multi-bladed spinning designs as unstable in his book *Starsailing* (Table, p.33).

Space Amateur Radio

Sir, With reference to *Spaceflight*, February 1995, p.57 and the picture (below) showing the ham radio shack on board Mir, I see that at the upper left is an IBM laptop PC AT which is used for packet communications. At the lower left, on a small tilted table is an ICOM IC228A/H, VHF-Transceiver.

Merbold, in the centre, was active during Mir's passes over Europe, talking to mainly German ham's using his callsign: DP3MIR.



On board Mir during the EuroMir 94 mission. Left to right: Taldat Musabayev, Ulf Merbold and Yelena Kondakova. ESA

In 1994 I heard the following callsigns active from Mir: R3MIR/3UMIR/U6MIR/DP3MIR, especially Polyakov/U3MIR who was very active.

Participating in the STS-60 SAREX were crew members: Charles Bolden, Commander, KE4IQB; Ronald Sega, Mission Specialist, KC5ETH; and Sergei K. Krikalev, Mission Specialist, U5MIR.



In 1995, a joint German-Russian ham project is expected to take place with the installation of a VHF/UHF/SHF-transceiver on board the Priroda module. Call: RR0MIR.

I enclose the QSL-card (below) that I received from the STS-60 mission. Mission highlights are printed on the back of the card:

Amateur Radio operators and students from schools in Idaho, Iowa, Maine, Pennsylvania and Moscow Russia contacted crew members aboard this flight of the Space Shuttle Discovery via ham radio. The activity was part of the Shuttle Amateur Radio EXperiment (SAREX).

The mission was the first US/Russian human space flight since the Apollo-Soyuz Test Project in 1975, and the first to involve Russian and American space travellers on the same crew. Throughout the flight, numerous microgravity experiments were controlled in the SPACEHAB-2 module. Communication difficulties with the Wake Shield Facility suspended deployment of the payload carrier. Russian Cosmonaut Sergei Krikalev also took part in joint US/Russian sponsored science activities.

J.K. ANDERSEN
Skagen, Denmark



Discovery 'On the Pad'.

Space Theme

Sir, During my trip to Japan last summer I visited the Space World theme park in Kitakyushu where I took this photograph of the full-sized replica of Space Shuttle Discovery. At appointed times throughout the day visitors can witness a 'lift off' or, more accurately, 'main engine ignition' complete with accompanying countdown, sound effects, music, lights and exhaust plume!

GARY SIMMONS
London, E18

Deceased Cosmonauts

Sir, Vadim Y. Molchanov's list of deceased cosmonauts/astronauts (*Spaceflight*, January 1995) gives the cause of Nelyubov's death as a railway accident. In fact, having been dismissed from the cosmonaut team for involvement in a drunken brawl and sent to the Soviet far east as an interceptor pilot, he became increasingly depressed and, while in an intoxicated state, threw himself under a train at Ippolitovka, north of Vladivostok. There seems no doubt it was suicide.

Shcheglov's date of death is given as 19 July 1973, but an authoritative source, Douglas B. Hawthorne's *Men and Women of Space* (Univelt, 1992) gives it as 18 October 1972.

Swigert's date of birth is given as 20 August 1931, but Hawthorne and other sources give it as 30 August.

Gulyayev's year of birth is given as 1938, while Hawthorne gives 1937; also, his date of death is given as 19 April while Hawthorne gives 19 May.

Finally, Hawthorne gives Petrushenko's date of birth as 10 January 1941, not 1 January 1942 as given in the list.

RAY WARD
Sheffield, UK

Deceased Cosmonauts and Astronauts

Sir, It was interesting to see the list of deceased cosmonauts and astronauts in the January 1995 *Spaceflight*. However a few were not listed:

Name and Country	Birth/Death Dates		Cause of Death
D.K. Slayton (USA)	01.03.24	13.06.93	Brain cancer
S.Y. Nozovikov (Russia)	17.04.58	11.07.93	Drowned
M.O. Thompson (USA)	04.05.26	06.08.93	Cardiovascular Disease
K.G. Henize (USA)	17.10.26	05.10.93	Pulmonary infection
Y.Y. Dreobrazhenski (Russia)	03.02.39	25.10.93	Car accident
A.F. Noronov (Russia)	11.06.30	31.10.93	Cancer
B.B. Yegorov (Russia)	26.22.37	12.09.94	Heart attack
S.A. Roosa (USA)	15.08.33	12.12.94	Pancreatitis

In addition, A.A. Rushworth about whom the author asked for information died on 17.03.93 from a heart attack.

ANNE van den BERG
The Netherlands

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Space Power Cable for the Next Millennium

Sir, The possibility of constructing orbiting solar power stations has been discussed for some years and has many attractions as an aspect of our solution to the problem of energy supply in the next millennium. A weakness of such schemes has generally been the means by which it is proposed power be transmitted to the Earth's surface, usually envisioned as occurring via a microwave (or, alternatively, a laser) beam. The necessary interconversions of energy into and from these forms are intrinsically inefficient and (especially in the latter case) there would be considerable risks associated with side effects of the beam, including possible beam misdirection.

I would like to suggest an alternative means for the transmission of power which, as far as I am aware, has not previously been considered in this context: that of the electric cable.

The possibility of constructing a 'space elevator', wherein a continuous cord of superstrong (but not impossibly strong material links orbiting facilities with the surface of the Earth such that a simple craft could ascend to orbit using electric drive motors, has also been discussed for some years. It is recognised that certain advances in materials science and technology would be called for before such a project could be carried out. But they do not appear to be impossible or even unlikely ones. The tensile strength of diamond, for example, would be more than adequate were that material available in appropriate form.

The suggestion made here is that an orbiting solar power station could be linked electrically to the Earth by means of a power transmission cable supported by such a cord (or made as a part of it). Conceivably the cable could be of relatively conventional design, being based upon those used for power transmission on the Earth's surface today, but it seems to me likely that the advances in materials science necessary to facilitate the cord itself would have been paralleled by others enabling the design of effective superconducting cables. Optimistically these would operate at ambient temperature, but even if they required cooling to the temperature of liquid nitrogen (as we should perhaps pessimistically recently assume) a working system ought not to be beyond engineering design.

It is my opinion that the synergistic combination of a basic space elevator with a cable-linked orbiting solar power station would be an attractive package, offering much to benefit the world and a powerful incentive to continue the push into space. I would greatly value any views or comments from others.

GEORGE MORRIS
Chesterfield, UK

The following comments have been sent to us by Ivor Franklin:

Firstly, the most desirable orbit for an SPS is geostationary above the Earth's equator. Looking at a globe of the Earth shows that the main land masses are equatorial Africa, South America, and Indonesia.

These, with the exception of Indonesia are very much undeveloped areas with inhospitable environments. Thus an SPS with a power link to Earth would not be connecting with a useful receptive area, although, climate apart, it could help these territories to develop. The NASA Reference Concept with a steerable laser or microwave beam gives much more flexibility with ground receiving sites, usually known as rectennas.

The next problem concerns orbit stability in terms of North/South and East/West station keeping. Communications satellites can drift some kilometres from their nominal reference position before the on-board propulsion subsystem moves them back again. However with an Earth tethered system this drift becomes a serious problem. Drift is due to gravitational variations, magnetic fields, and solar pressure, and is unavoidable and difficult to predict. Some drift may be acceptable during construction, but when operational the CG must be fixed relative to the Earth terminal.

The next point concerns the cable itself, its material and construction. I believe that a system that uses a separate electrical conductor and tether is essential, and the whole cable system needs to be redundant for both safety and power continuity reasons.

The electrical conductor could be made of a single crystal diamond which is very strong and an excellent conductor with good thermal characteristics. However making a 36,000 km single crystal diamond cable poses some very severe problems. Raw material availability, processing plant and deployment system come to mind. While power would be available from the SPS in large quantities initially, there will be significant solar degradation over the very long period needed for on-board manufacture of the diamond conductor. Thus supply logistics will become another job. Such a complex operation would certainly require manned activities over very long periods in a potentially dangerous environment. Potential hazards include very high voltages and currents, heat dissipation, radiation fields and micrometeorites.

Such a cable must be grown from space downwards, implying some form of space cable ship. Without getting too technical, growing a cable downwards poses system dynamic problems. Essentially to maintain the cable ship in a constant position in space will require a complex system of gravitational counter balances to maintain equilibrium. This implies growing a structure outwards from the cable ship as the conductor and tether extend downwards.

Next the question of how much power. The NASA Reference SPS chose 12Gw per SPS which after conversion was assumed to provide about 5Gw at the rectenna. For comparison 5Gw is about equal to 2 modern nuclear power stations. Although 5Gw is large, it is felt to be appropriate because of the enormous investment required. Converting this power into volts and amps gives 90,225 amps at 133,000 volts. This voltage is typical for high power terrestrial landlines. Without doing the sums it is clear that the size and hence mass of the conductor will be very large; all of which must be delivered to orbit in some form. System redundancy is essential because total power loss is unacceptable.

Assuming the cable system can be produced, the question of how it responds to atmospheric disturbances close to Earth will require a lot of attention, bearing in mind the likely response of a comparatively small

diameter cable over some 36,000 km with no aerodynamic damping beyond say 50 km - the tail will surely wag the dog!

Arthur C. Clarke deals with some of these points in his book *Fountains of Paradise* in the context of his concept of a Space elevator.

Another major issue is who pays for it, who owns it, and how is it charged as a tariff. Also for coverage of the areas mentioned earlier, a number of SPS's would be needed. As you may imagine, even with this quick assessment, the technological problems and the financial, legal and institutional aspects are truly enormous.

So in summary, the above letter suggests an interesting idea, but is one beset with a great many problems that are beyond any current or foreseen technology and industrial capability. My points are obviously not comprehensive, but perhaps adequate to give a feel.

There are other candidate materials for the conductor besides diamond, such as copper, but there are trade-off aspects to be considered and the problem remains truly enormous.

Earth-Moon Tours

Sir, Since so little money is available for space research these days, it seems to me that every ounce of use must be extracted from existing resources. Thinking in this vein, I wonder what is planned for the Russian Mir complex once the International Space Station is built? Must it suffer the same fate as Skylab? I think some constructive and original use should be found for it.

I have a suggestion, although I have no knowledge of the technical feasibility. It could be boosted by stages over a period of years to a higher and higher elliptical orbit, e.g. several thousand miles by two hundred miles. It would benefit man's personal exploration of these regions, which have only previously been reached for brief interludes by Apollo astronauts.

In years to come it might be possible to contemplate the complex being boosted into a permanent Earth-Moon loop. Ultimately perhaps it could become the first living space museum, and one could envisage it being visited by tourists of the 21st Century.

JOHN SILVESTER
Bedfordshire, UK

Philip E. Cleator

Sir, I should like to congratulate Dr L.R. Shepherd on the excellence of his tribute to the late Philip E. Cleator (*Spaceflight*, December 1994 pp.428-429). His recollections of the founder of our Society reminded me of the scepticism and outright hostility that the pioneers faced in presenting the case for space travel in the 'Thirties and 'Forties. Cleator was one who held a straight bat throughout - and never flinched.

His books, *Rockets Through Space* (1936) and *Into Space* (1953) did much to stimulate interest in rocket propulsion and space flight in this country and abroad. We owe him a great deal.

KENNETH W. GATLAND
Ewell, Epsom, UK

30 Years Ago . . .

Dramatic Space Walk No. 1

Nearly Met Disaster

In 1965 Alexei Leonov Became the First Man to 'Walk' in Space

At 10.00 am Moscow Time on 18 March 1965, Voskhod 2 roared off its launch-pad at the Baikonur Cosmodrome and reached very close to its calculated orbit of 497.7 x 173.5 km at an inclination of 64.79°.

It carried two cosmonauts, Pavel Ivanovich Belyayev, commander, and Alexei Archipovich Leonov, pilot. Immediately after entering orbit they set about making preparations for Leonov to make man's first space walk.

With Belyayev's help Leonov put on a life support backpack over his pressure suit and began breathing pure oxygen, which he did for more than an hour before his 'walk-out'.

It may be noted that in the cabin of their spaceship the cosmonauts were breathing an oxygen/nitrogen atmosphere. Therefore Leonov had to purge his blood of the nitrogen because in open space he would experience a lack of pressure and the nitrogen in his blood would form possibly fatal bubbles and he would suffer from the bends. The backpack also provided devices to regulate the temperature in the spacesuit. To keep connected to the spacecraft Leonov attached a 5.35 m long tether that enclosed a radio-telephone link to his spacesuit.

On the second orbit, after ensuring the integrity of the air-lock he opened the inner hatch (inward) and with a 'Good Luck' from Pavel Belyayev floated into the air-lock chamber.

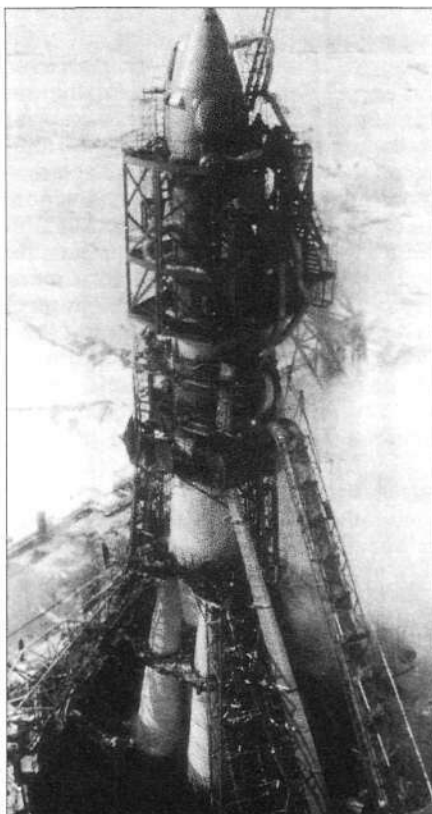
The air-lock was of a simple and ingenious design with an accordion-type tunnel attached to one of the two cabin hatches. On the side of the spherical Voskhod capsule, beside the pilot (here Leonov) there was a removable circular hatch on the outside of which the air-lock was attached. During launch it was kept in a compressed configuration, but after reaching orbit and jettisoning the fairing the air-lock was extended and pressurized.

After pushing himself through the

Pavel I. Belyayev.



BY E. RUDOLF van BEEST
The Netherlands



Voskhod 2 on its launch pad at Baikonur on 18 March 1965. The 'blister' atop houses the compressed air-lock.

hatch into the air-lock chamber, Leonov pressurized his suit and checked to make sure that it was airtight and that the helmet was adjusted properly. Then Belyayev closed the hatch and depressurized the sealed chamber. Finally, Leonov opened the outer hatch and at 1134 h 51s he became the first man to 'walk' in space. "When I was ready to go, I gave a little push and popped out of the hatch like a cork", Leonov later recalled.

Leonov did more than just float and turn somersaults. His efforts included among others the dismantling of a movie camera and the removal of several objects from the outside of the capsule. In fact he proved that a man could work in open space and survive, given the protection of a spacesuit and a life-support backpack.

After about ten minutes Belyayev



Alexei A. Leonov.

notified Leonov that he was to return to the air-lock and terminate his spacewalk. As we now know, this was the moment the trouble started. At first Leonov reported difficulties in retrieving the exterior movie camera and when he tried to put it into the air-lock it floated out, again and again. At last Leonov pushed it (once more) into the 'tunnel' and put his feet on it and this helped it to stay where it was. The space walk and the struggle with the

A model of the Voskhod 2 air-lock exhibited in the NPO Energiya museum.

E.R. van BEEST





Leonov was seen on TV climbing out of the air-lock.

camera tired Leonov very much. He was sweating profusely and producing more perspiration than his suit could

absorb.

Then, with his feet already in the air-lock, a much more serious problem arose. He could not get back in himself. The lack of external pressure on the spacesuit in the vacuum of space had caused the suit to balloon more than expected. With sweat covering his eyes and unable to clear them because of the helmet and with a pounding heart, he reduced the suit pressure. Once, no good.... Twice, no good.... After the third attempt he succeeded. He had reduced the pressure to a very risky low level, from 0.4 to 0.25 atmosphere, which was in fact under the permissible limit, but now he could clamber back in.. Alive! He had been 10 minutes in open space and 12 minutes struggling to get back in. After Leonov's return the expendable air-lock was jettisoned.

However, troubles were not over yet. As Belyayev prepared for the automatic firing of the retro-rockets at the end of 16th orbit, a signal indicated that the automatic guidance system had malfunctioned and the spacecraft was not properly oriented for the return to Earth. This meant that the spacecraft had to fly on for one more orbit. Belyayev and Ground Control discussed the problem and then Belyayev was given permission to attempt a manual re-entry at the end of the 17th orbit. At the proper time he manoeuvred Voskhod 2 into the correct position and fired the braking rockets.

The re-entry was a hot and scary one. It was so hot that all the communications airdials were burned off and the cosmonauts saw molten metal running down the portholes. Nevertheless, they came down safely, although as a result of the extra orbit the cosmonauts landed about 1300 km off course. They came down in a remote, snow-covered area on the slopes of the Ural Mountains. The spacecraft landed between two big fir trees with the parachutes snarled high up in the trees. Search helicopters located the landing site and food and warm clothing were dropped, but the helicopters could not land and the two men were forced to spend the rest of the day and the night near the capsule. Lumberjacks made a makeshift helicopter landing pad and the rescue party had to ski about 20 km to the cosmonauts' touchdown area. Finally, they were found and left the landing site with the rescue party on skis. After reaching the clearing they were picked-up and flown to Baikonur.

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 Nicholas L. Johnson, *Handbook of Soviet Manned Spaceflight*, Vol. 48, pp. 76-83, 1980.
 Gene and Clare Gurney, *The Soviet Manned Space Programme* (Cosmonauts in orbit), pp. 103-110, 1972.
 Phillip Clark, *The Soviet Manned Space Programme*, pp. 29-30, 1988.
 P.L. Smolders, *Russen in de Ruimte*, pp. 125-132, 1971.

The Voskhod 1 and 2 capsules on display in the NPO Energiya museum. Voskhod 2 is on the left and the plane surface seen on its outline is the second cabin hatch to the exterior of which the air-lock was attached.

E.R. van BEEST



November 1994 - January 1995

Mir Space Station Update

Summary: The suspect Kurs docking system has now been tested in preparation for the arrival in May of the Spektr module. The test was made after the earlier docking problems with Progress M-24 and Soyuz TM-20 and a fault was found in the software for the Kurs docking system.

The three person crew of the Mir complex have been continuing their scientific work following the cancellation (reported in the last issue) of EVAs to move solar arrays from the Kristall module to the Kvant astrophysics module.

Experimental Work in Orbit

Following the Euromir-94 mission, the Mir crew consisted of Commander Aleksandr Viktorenko, Flight Engineer Yelena Kondakova and Physician Dr. Valeri Polyakov.

The main thrust of their work was in medical studies as Polyakov and Kondakova both continued towards new records for duration in orbit.

Two days were spent unloading the unmanned cargo ship Progress M-25 and installing new equipment on the station to replace equipment which had passed its useful life. Then preparations were made for refuelling the tanks of the Mir base block using fuel and oxidiser delivered by Progress M-25.

Over the following days Dr Polyakov continued to evaluate health checks on the basis of the results of blood tests and the use of an ultra-sound device.

The French Nausica apparatus was in use to obtain information on the radiation situation in orbit. The crew also studied the sound intensity in the station's living modules.

By mid-December they had carried out a great deal of work on the human cardiovascular system and psychophysiological responses and on their physical capacity for work. The astrophysical work continued and included measurements of spectra at various wavebands and the recording of galactic and extra-galactic X-ray sources.

The flight programme for December 20 included radiation studies and the measurement of micrometeorite fluxes along the velocity vector to study their effects on materials and radio components mounted outside the complex for extended periods.

December 21-23 were busy days with the cardiac function and visceral circulation of Viktorenko and Kondakova being examined using an Echograph scanner. Polyakov also studied his own physical performance and vestibular function.

New Year in Orbit

On December 27 the Russians announced that the Mir complex was currently in an orbit of 412 x 391 km, period 92.3 minutes and inclination 51.6 deg. For the cosmonauts the year concluded with a cleaning up of the complex and yet more medical

BY NEVILLE KIDGER FBIS

Leeds, UK

studies.

The crew spent the first week of 1995 on astrophysical, geophysical and medical experiments. The astronomical research involved X-ray studies of sources at the galactic centre.

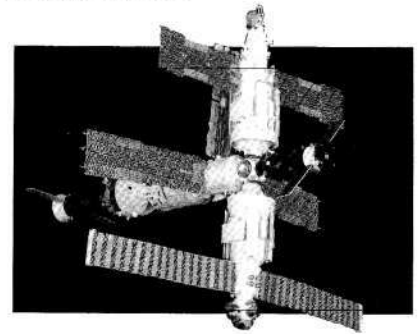
On January 9 Dr. Valeri Polyakov broke the duration record set for a single space flight. The existing record was set by Vladimir Titov and Musa Manarov between December 1987 and December 1988.

Polyakov is set to spend over 460 days on this mission. He already had 241 days of space experience to his credit when his current mission began on 8 January 1994.

Docking

On 11 January the Russian press announced that the cosmonauts were to test the docking mechanism of Soyuz TM-20 that day.

The Kurs system had malfunctioned during the docking of TM-20 on 6 October 1994 and Viktorenko had been forced to override the system and dock manually with Kondakova providing data from the Soyuz Orbital Sec-



tion during the approach.

The three crew members floated into the Soyuz capsule and undocked at 0900 GMT. Viktorenko backed the Soyuz away from the front axial docking port of Mir until the separation distance was 160 m.

The Kurs system was then commanded to bring TM-20 automatically to a safe docking. Twenty-six minutes after the undocking TM-20 was docked with the front port again.

Following the initial analysis of the test the original problem encountered during the TM-20 docking was described as a "casual technical malfunction". However, plans were afoot to examine the system in detail again.

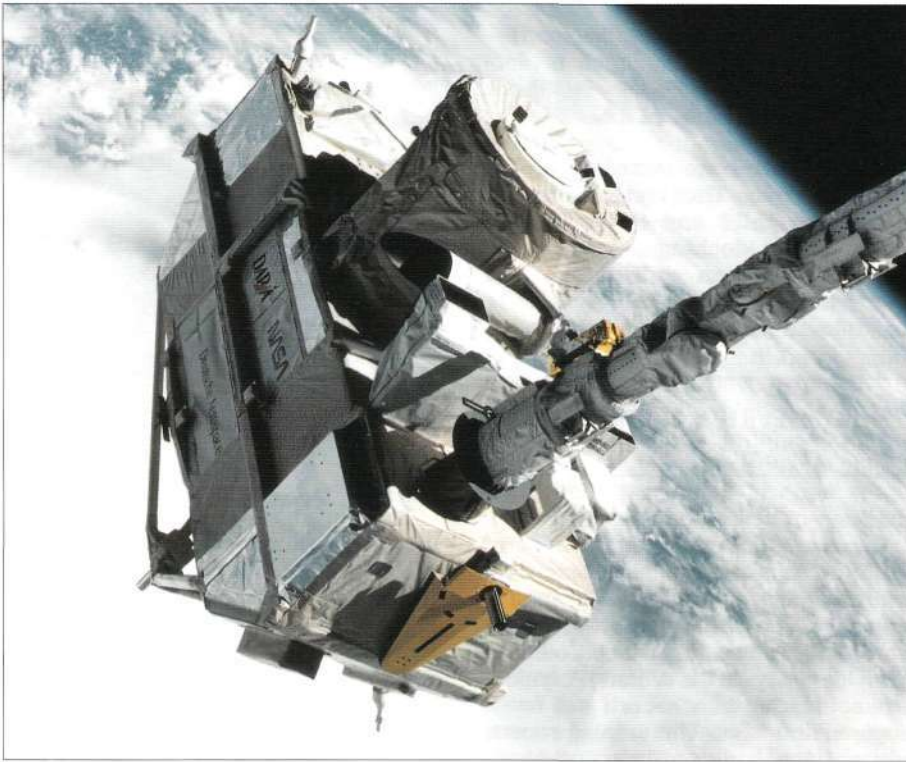
The results of this analysis, reported by Videokosmos, showed that the deviations of the system during the approach amounted to just 0.5 degree, well within acceptable limits. Radio communication had been maintained by means of the geostationary relay satellite Altair.

The test clears the way for the much-delayed docking of the Spektr Module following its launch in mid-May.

Crew picture of the next manned mission to Mir which is due for launch on 14 March. NASA astronaut Norman E. Thagard (left) poses with Russian cosmonauts Vladimir N. Dezhurov (centre) and Gennadiy M. Strekalov (right). See p.107 for details of 1995 manned space flight missions prepared by A. v.d. Berg, courtesy of whom this picture was supplied.

NASA



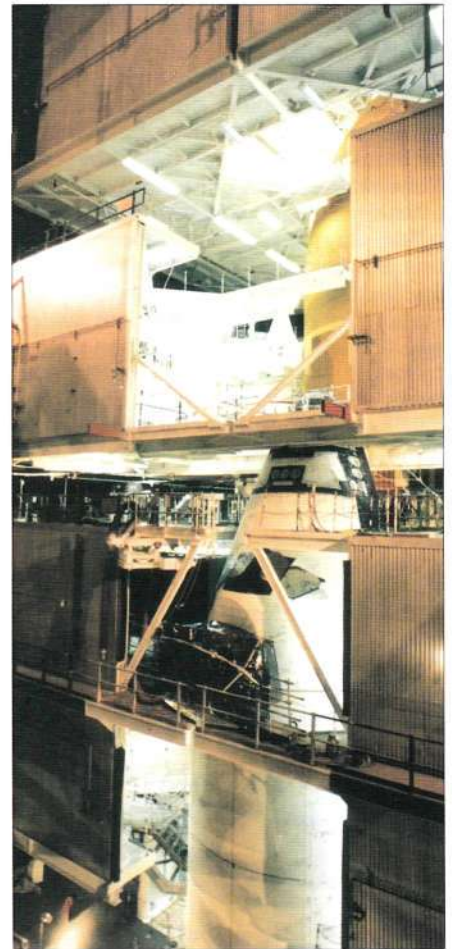


Payload Deployment

Left: A 70mm shot of the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) attached to the Shuttle Pallet Satellite (SPAS). CRISTA-SPAS is being held by the Shuttle RMS arm and was deployed on 4 November 1994 remaining in free-flight until it was retrieved by the RMS arm on 12 November 1994.

NASA

Vehicle Preparation



The External Tank's oxygen vent looks a simple and relatively small device from a distance; but not so at close quarters. A worker exiting the right side of the vent cap may just be picked out.

PETER GUALTIERI, WEST KENTUCKY NEWS



Cocooned in steel scaffolding Atlantis sits on the mobile launch platform in the Vehicle Assembly Building on 5 October 1994 prior to its rollout on 10 October. A part of the External Tank can be seen through the scaffolding and to the left of it the frustum of a boost motor can be seen in outline.

The forward section of Atlantis is clearly visible and a black plastic tent on the gangway covers the outer overhead window. A scratch was discovered on this window and a replacement borrowed from Columbia was in the process of being installed.

PETER GUALTIERI, WEST KENTUCKY NEWS

Recovery

Left: On board NASA's recovery ship *Freedom Star* on 5 November 1994 with a spent booster on deck. A crew man is removing a navigation light from the rear of the STS-66 left-hand booster where it is bolted through one of the SRB hold-down points.

PETER GUALTIERI, WEST KENTUCKY NEWS



STS-66 astronauts arrive at KSC on 31 October 1994. Left to right: Jean-Francois Clervoy, Scott E. Parazynski, Joseph R. Tanner, Donald R. McMonagle, Ellen S. Ochoa and Curtis L. Brown Jr.
PETER GUALTIERI, WEST KENTUCKY NEWS

Atlantis Flies After Two Years

Atlantis lifted off from the Kennedy Space Center's launch pad 39B shortly before noon on 3 November 1994 having returned on 29 May 1994 from its California manufacturing site where it underwent an extensive overhaul and modification.

Preparation and Countdown

Following its return, Atlantis was prepared for the upcoming STS-66 mission in the Orbiter Processing Facility work bay 3 and after payload and engine installation was moved to the Vehicle Assembly Building on 4 October where it was mated to its external tank and booster rockets. The assembled Shuttle was then transported to launch pad 39B on 10 October 1994.

After loading the SPAS satellite into Atlantis' payload bay routine launch pad operations involved verifying the Shuttle to pad interfaces, countdown simulation, loading hypergolic propellants, closing out the launch vehicle, and entering the countdown. KSC picked up the countdown clock at 4:00 pm on 31 October with a projected lift-off time of 11:56 am on 3 November.

The crew were awakened at 7:01 am on 3 November, had breakfast and, after weather briefings and putting on their flight equipment, left the KSC Operations and Checkout Building and arrived at the white room atop launch pad 39B's service structure at 9:11 am. Final equipment checks were followed by the crew entering Atlantis and the hatch was closed about 10:26 am.

Although weather at the Florida launch site was perfect with clear cloudless skies, low wind speeds, and moderate temperatures; weather was a concern during the final hours of the countdown. A frontal system was moving across the European-African area and the trans-Atlantic abort sites were

BY ROELOF SCHUILING
at the Kennedy Space Center

all indicating unacceptable weather measurements during the morning - especially with regard to crosswinds at the abort sites runways. As the countdown continued, however, Ben Guerir Morocco showed a clearing trend and an hour before projected launch the crosswind was 20 knots and falling. The specifications for crosswinds were 15 knots in daylight and 12 knots at night. Ben Guerir had approximately 20 minutes of daylight at the 11:56 am launch time. A half hour before the planned launch time the crosswinds were at 18 knots.

The countdown proceeded on schedule until the T-5 minute point - the last major point before starting the auxiliary power units and beginning the liquid oxygen drainback. The report from Ben Guerir was good with cross winds now at the 15 knot point. The launch team and management team members had decided to hold at that point for a final assessment. The analysis showed that the countdown could continue and, after a final check that all systems and managements were okay, the count was restarted. The final moments of the countdown proceeded smoothly, the main engines ignited and then the solid boosters. Atlantis lifted off at 11:59:43:060 am on 3 November 1994 arcing to the north-east on to a 57 degree inclination flight path. The booster rockets burned out and separated at 2 minutes and 4 seconds and the main en-

ATLANTIS

Orbital Flight:

3 - 14 November 1994

gines cut-off at 8 minutes 36 seconds. The orbital manoeuvring engines were fired at 39 minutes for approximately 2 minutes 42 seconds to circularise Atlantis into a 163 x 165 nautical mile orbit.

Flight Day One

Atlantis' six person crew was divided into two shifts - the "Red Team" was composed of Donald McMonagle, Ellen Ochoa and Joseph Tanner; while the "Blue Team" was made up of Curtis Brown, Scott Parazynski and ESA astronaut Jean-Francois Clervoy.

The Blue Team's first sleep period began at about 4 hours into the mission. Meanwhile, the Red Team was active with preparations for the release of the German-built Shuttle Pallet Satellite (SPAS) and its instruments. Ellen Ochoa used the orbiter's robot arm to grapple the satellite and power up its systems in preparation for the deployment which was set for the following day.

The ATLAS-3 spacelab payload was also activated during the first afternoon, as was the Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument. By about 11 hours into the mission the Red Team began its first sleep period after handing over to the Blue Team.

Flight Day Two

The highlight of the day was the release of the SPAS satellite carrying the

On the Atlantis middeck, Donald R. McMonagle works with the Heat Pipe Performance experiment. This experiment investigates the thermal performance and fluid dynamics of heat pipes operating with asymmetric and multiple heating zones under microgravity conditions. NASA



Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) and the Middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI) instruments. Jean-Francois Clervoy used the robot arm to lift the satellite clear of the payload bay and released it at 7:50 am (all times are KSC times). After receiving several hours of initiation commands from the operations team at KSC the instruments made their first observations during the afternoon. Science operations were halted for several hours when the satellite's guidance system lost sight of its reference stars in mid-afternoon, however, ground commands successfully reoriented the satellite.

Back on the ATLAS-3 payload in the orbiter's payload bay the mission's first solar observation period began at midday. The observations were designed to measure the Sun's energy during the daylight portions of eight orbits. The Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment got two bonus observations of orbital sunsets and measured trace gases in the atmosphere over northern Europe. The Active Cavity Radiometer Irradiance Monitor (ACRIM) from NASA's Jet Propulsion Laboratory and the Belgian Solar Constant experiment (SOLCON) were active making measurements of the Sun's irradiance. France's Solar Spectrum (SOLSPEC) experiment concentrated on measuring solar radiation as a function of wavelength at infrared, ultraviolet, and visible wavelengths.

Ellen Ochoa was successful in locking on to four Global Positioning Satellites to provide the ATLAS-3 teams with an additional precise measurement of their instruments' location in space. The primary source of position information is the Shuttle's Inertial Measurement units.

As the day drew to a close, the SPAS satellite was about 22 nautical miles behind Atlantis and separating at a rate of about three miles per orbit.

Flight Day Three

The ATMOS experiment observed orbital sunrises around the South Pole in a study of ozone amounts inside and outside of swirling "polar vortex".

By the middle of the day, Atlantis was separated from SPAS by 42 miles and separating at two miles per orbit.

For the first time, scientists at the Marshall Space Flight Center in Huntsville, Alabama were completing analysis of the ATMOS observations within 24 hours and comparing their results with observations from the Total Ozone Mapping Spectrometer aboard the Russian Meteor-3 satellite. The rapid data reduction represented a major improvement over previous ATMOS flights on ATLAS-1 and 2. The automated data processing system compressed months of data reduction into hours.

Flight Day Four

ESA astronaut Clervoy devoted several hours of his shift working with a heat pipe experiment in the middeck area. The Heat Pipe Performance experiment (HPP) was designed to evaluate fluid transfer through various kinds of pipes which might be used on future spacecraft. During Red Team shift operations Don McMonagle took over work with the HPP.

Atlantis was now station-keeping 48 nautical miles ahead of the SPAS deployed satellite as it orbited once every 90 minutes at an altitude of approximately 164 x 160 nautical miles. After 30 hours of data collection, the CRISTA instrument had measured more than three million infrared spectra of trace gases in the Earth's atmosphere. CRISTA was collecting data at the rate of 26 spectra per second during its studies of the distribution of atmospheric trace gases between altitudes of 30 and 150 km.

The MAHRSI experiment, aboard the satellite, was studying hydroxyl spectra in the middle atmosphere. Later, during the morning, the MAHRSI instrument began taking readings of nitric oxide at high altitudes. Both

About the Crew

The crew included three astronaut veterans and three who were making their first trip into space.

Mission Commander **Donald R. McMonagle**, 42, Lt. Col., USAF was selected as an astronaut in 1987 and was making his third flight into space. He had previously flown as Mission specialist on STS-39 in April 1991 and as Pilot on STS-54 in January 1993. He had over 343 hours of space flight prior to STS-66.

Pilot **Curtis L. Brown**, 38 Lt. Col., USAF was selected as an astronaut in 1987 and was making his second flight having flown as Pilot of STS-47 in September 1992. He had more than 190 hours of space flight.

Dr **Ellen Ochoa**, PhD, 36, who was Payload Commander and Mission Specialist-One, was selected as an astronaut in 1990 and had flown over 216 hours in space as Mission Specialist on STS-56 in April 1993.

Joseph R. Tanner, 44, was Mission specialist-Two on STS-66 and was selected as an astronaut in 1992 after having worked for NASA as an instructor pilot with the Shuttle Training Aircraft project.

Missions Specialist-Three was **Jean-Francois Clervoy**, 35, who was selected as an ESA astronaut in 1992.

Scott E. Parazynski, MD, 33, was Mission Specialist-Four and was selected as an astronaut in 1992.

hydroxyl and nitric oxide are active in the natural cycle of ozone chemistry.

During the evening the orbiter manoeuvred for one orbit so as to relay communications between the CRISTA and MAHRSI instruments and the ground by going through Atlantis' communications. This enabled real-time calibrations and adjustment to the instruments on the satellite to be made.

Flight Day Five

Throughout the night comparisons of data from the ACRIM and SOLCON experiments were made as well as comparisons with data from the Upper Atmosphere Research Satellite (UARS) which was deployed from Discovery on STS-48 in 1991. ATLAS's instruments are carefully calibrated before and after each mission and, therefore, their readings can also be used to calibrate readings from satellites whose instruments may have changed over time. This allows scientists to track subtle changes in solar energy over long periods of time.

The Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) instrument on ATLAS-3 also provided a chance to calibrate the SUSIM on the UARS satellite. The UARS SUSIM has been decreasing in sensitivity since its deployment - an expected condition due to the severity with which ultraviolet radiation impacts instruments in space. Here too, scientists can use the ATLAS-3 data to evaluate and correct for that degradation.

The overnight observation period lasted until about 8:30 am when another communication link-up between the SPAS and ground controllers was set up by Atlantis. The communication period was extended for about an hour so that the MAHRSI experiment on the satellite could have its pointing refined by extra calibrations with guide stars. Atlantis performed a slight engine burn to control the distance to the SPAS satellite. At this point the orbiter was 47 nautical miles away and extending the distance by about 1 mile per orbit.

During the evening the SPAS completed another period of communications with Atlantis, during which the CRISTA instrument was turned through two degrees from looking at the Earth's atmospheric limb to looking directly at the Earth in order to verify the instrument's position. It was then turned back to continue studies of the high atmosphere and acquired about 4,000 height scans of trace gases each day.

Flight Day Six

Curt Brown performed a small engine burn just after 6:00 am to refine Atlantis' orbit ahead of the SPAS satellite.

Throughout the day the Red Team worked with ATLAS-3, manoeuvring the orbiter to provide the instruments

with the best views of the Earth and Sun. Red Team members also worked with the middeck science experiments, including the Protein Crystal growth and Space Tissue Loss experiments which provided data needed to validate Earth-based models of how microgravity affects the human body.

Flight Day Seven

Curt Brown performed a small burn to maintain Atlantis' range from SPAS. Together with Mission Commander McMonagle he continued to manoeuvre Atlantis so that the orbiter's attitude supported ATLAS-3 observations as required. Ellen Ochoa told controllers that the crew could see as many as 13 to 14 layers in the atmosphere above the clouds during sunsets and Mission Commander McMonagle said they were collecting photographs of the sunsets with a 300 millimetre lens to supplement the data obtained by the instruments. The ATMOS team had asked the crew to obtain as many photographs as possible.

During the morning, the SUSIM, SOLSPEC and SSBUV teams announced that their data agreed within five percent. This is the closest agreement ever achieved by three instruments without extensive post-flight calibration. The data correlation is especially significant as the three instruments use different physical principles.

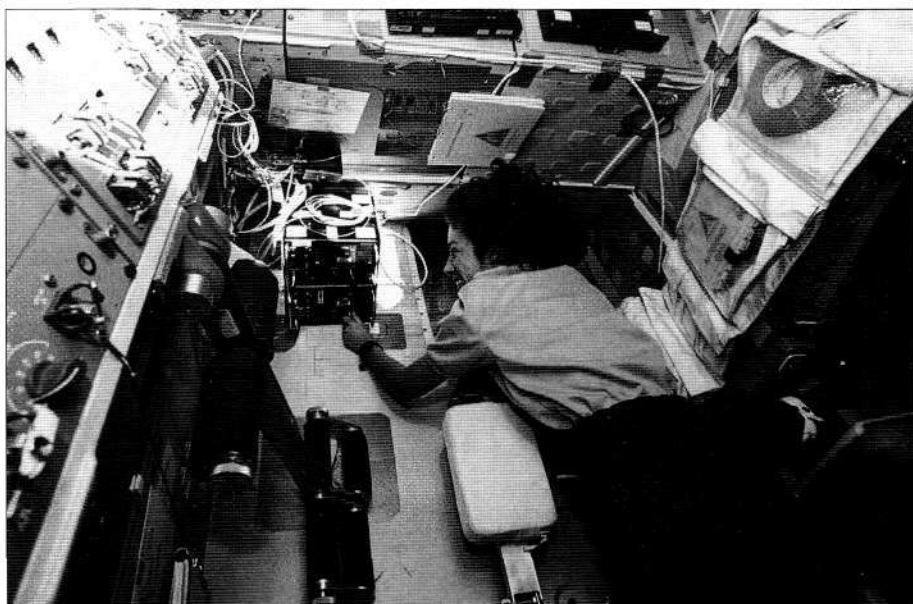
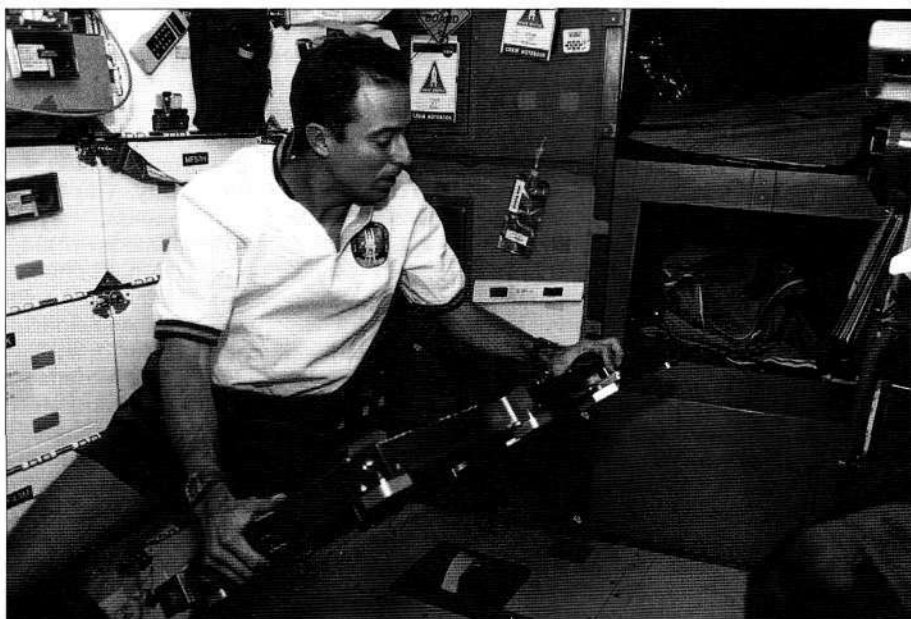
Flight Day Eight

By this time in the mission CRISTA had taken over ten million infrared spectra of trace gases - enough to fill six thousand computer discs.

Overnight MAHRSI scientists used the internet to research old data records from the 1978 International Ultraviolet Explorer (IUE) satellite's Moon observations to provide an atmosphere-free ultraviolet spectrum

Jean-Francois Clervoy, ESA mission specialist, moves a platform for the recumbant seat device which was being evaluated for a future Space Shuttle flight. The platform is part of a middeck arrangement designed to accommodate crew members when the Space Shuttle docks with Mir.

NASA



On the aft flight deck, Ellen Ochoa checks out a pair of 8mm video tape recorders associated with the Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment. On the left is the lower body restraint device installed in Atlantis to support crew members spending long periods of time in a stationary position on the aft flight deck. NASA

with which to compare their instrument's readings as a reference.

Meanwhile, instrument observations continued aboard SPAS and with the ATLAS-3 and SSBUV instruments in the payload bay. Data gathered by the ATMOS experiment were nearing the capacity of the instrument's onboard recorder and plans were made to downlink data through the Tracking and Data Relay System Satellite (TDRSS) system during the remainder of the mission.

Flight Day Nine

The Red Team were awakened at 3:00 am in preparation for beginning their work day at 7:00 am and a flight control system checkout was performed while all six crew members were awake so that the Commander,

Pilot and Mission Specialist engineer could perform the necessary checks in preparation for the upcoming landing.

After a connection between the computer and the Mass Memory Unit (MMU) proved faulty the crew switched the orbiter computer that was being used for systems management to a backup MMU. Both the computer, which is one of five flight control computers, and the MMU were in perfect condition and only the connection proved to be a problem.

Flight Day Ten

Overnight, the CRISTA and MAHRSI experiments aboard SPAS collaborated in taking simultaneous observations of the Moon in ultraviolet and infrared. The observations provided an atmosphere-free reference for data processing. This was similar to, but an improvement on, the internet IUE data obtained previously.

The SSBUV instrument was temporarily shut down after having completed 73 Earth observation periods, as were the ATLAS-3 instruments, in preparation for the retrieval of the SPAS satellite by Atlantis.

During the early morning hours the Blue Team manoeuvred Atlantis into position for the rendezvous and capture of SPAS. The Red Team took over the final phase of the operation and Mission Specialist Tanner was able to use the laser device to provide range and rate data. Commander McMonagle tested a new rendezvous method which will be used to rendezvous with the Russian space station Mir. The method requires the Shuttle to approach from below its target to minimise the effects of thruster jet plumes which might contaminate the station's instruments and solar arrays.

During the approach of Atlantis to the satellite the MAHRSI instrument

took ultraviolet observations of the orbiter to study the phenomenon of Shuttle "glow" and its possible interference with future Shuttle instrument performance. Payload commander Ochoa used the orbiter's robot arm to grapple the satellite at about 8:05 am on orbit 141. The satellite was returned to the payload bay and latched down at about 10:05 am after which Ellen Ochoa used the arm's television to check an icicle which had formed near the orbiter's payload bay door following a routine water dump. The television confirmed the ice was not near a hinge or latch and posed no danger.

Flight Day Eleven

Two landing times were available at the Kennedy Space Center on the following day, but a tropical storm off the coast of Florida was a concern and two landing opportunities were also available at the California Edwards Air Force Base landing site.

It was decided not to try to dislodge the icicle near the left payload bay door as the television camera on the robot arm had malfunctioned and controllers elected not to try to dislodge the icicle without visibility since it posed no threat and was not a safety issue.

Flight Day Twelve

The weather at the Florida landing site on 14 November did not improve and mission managers elected to go directly to California as no improvement at Florida was forecast.

Accordingly, Atlantis begin its re-entry operations and proceeded to land on the first landing opportunity for Edwards Air Force Base. The wheels of Atlantis' main landing gear touched down at 10:33:45 am (KSC-time) on runway 22. Nose gear touchdown was at 10:33:56 am and wheel stop was at 10:34:34 am. The mission had lasted 10 days, 22 hours, 34 minutes and 51 seconds. This was the 13th flight of Atlantis and had covered 175 orbits.

Later that day the crew returned to Houston and Atlantis began preparations to return to the Kennedy Space Center aboard the Boeing 747 carrier aircraft. Atlantis' next mission will be the STS-71 mission in May 1995, which will feature a docking with the Russian Mir space station.

'Shuttle Acronyms'

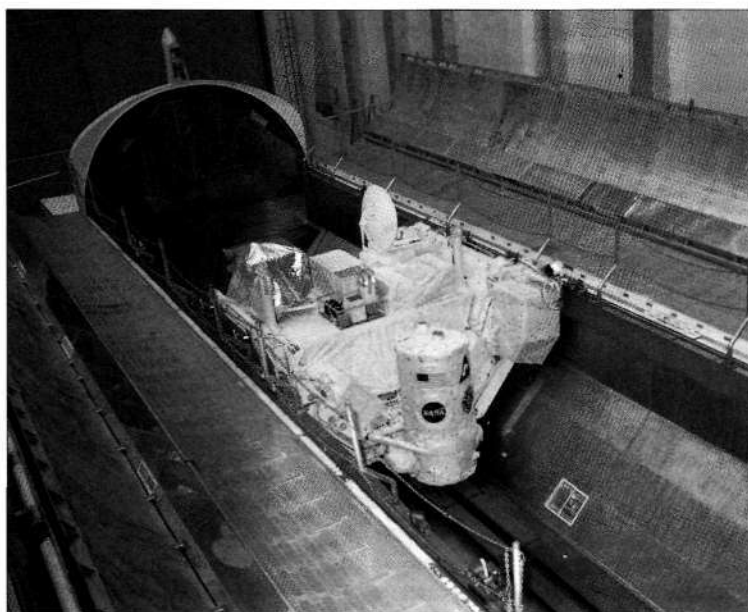
Competition Winners

Winners to whom video prizes will shortly be dispatched are:

G. Buckley	Rochdale, UK
A.L. Soden	Shrewsbury, UK
C. Massimo	Rome, Italy
N. McLaren	Oxon, UK

The correct answers are: 1. Laser Geodynamics Satellite; 2. Lidar In-space Technology Experiment; 3. Orbiter Processing Facility; 4. Portable In-flight Operations Trainer; 5. Shuttle Amateur Radio Experiment; 6. Upper Atmosphere Research Satellite.

STS-66 Payloads



In the Operations and Checkout Building on 19 August 1994, ATLAS-3 has been transferred from a test stand into the payload canister for transfer to the Orbiter Processing Facility where it was installed in the payload bay of Atlantis on 22 August.

NASA

The primary objective of STS-66 was to orbit a Spacelab pallet as a science platform for experiments in atmospheric science and to deploy and retrieve a satellite platform for associated experiments (*Spaceflight*, September 1994, p.316, January 1995, p.16).

Nine environmental instruments were carried as a continuation of NASA's Mission to Planet Earth, the payload being designed to map seasonal variations in the distribution and levels of ozone, chlorine monoxide, and over 30 other gases in the middle atmosphere and to measure the solar energy output that affects this region of the Earth's atmosphere.

The Atmospheric Laboratory for Applications and Science (ATLAS-3) contained seven experiments which had flown on ATLAS-1 in March 1992 and ATLAS-2 which flew in April 1993. Those previous ATLAS missions were STS-45 and STS-56. ATLAS-3 was the third in a series of up to nine NASA Shuttle flights designed to measure the variation in solar output and its effect on the Earth's atmosphere.

The Atmospheric Trace Molecule Spectroscopy instrument was used to measure concentrations of over 30 gases in the middle atmosphere, including water vapour, ozone, methane, chlorine, nitrogen compounds and CFCs. The Millimeter Wave Atmospheric Sounder recorded the distribution of water vapour, chlorine monoxide and ozone at altitudes of 12 to 60 miles. The payload bay wall-mounted Shuttle Solar Backscatter Ultraviolet Spectrometer instrument was a veteran of previous ATLAS flights and many other shuttle missions and serves to calibrate ozone measuring instruments on orbiting satellites.

Solar science instruments on ATLAS-3 measured solar energy output in order to study how varying levels affect atmospheric processes. The instruments included the Active Cavity Radiometer Irradiance Monitor, Measurement of the Solar Constant, Solar Spectrum Measurement instrument and the Solar Ultraviolet Spectral Irradiance Monitor.

Two new instruments, the Cryogenic Infrared Spectrometers and Telescopes for Atmosphere experiment (CRISTA) and the middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI) were mounted aboard the deployable Astronomy Shuttle Pallet Satellite Carrier (ASTRO-SPAS). The SPAS is a free-flying autonomous spacecraft which was developed by the German Space Agency as a science platform for Shuttle missions. The 7,500 lb satellite is approximately 15 feet high and 7 feet in length. It was mounted behind the ATLAS-3 pallet in the payload bay. The ATLAS-3 pallet payload was loaded into Atlantis' payload bay on 22 August 1994 while the orbiter was in the Orbiter Processing Facility. The SPAS was loaded into the payload bay at the launch pad on 11 October 1994.

The payload bay also contained a Get Away Special canister with an experiment which obtained extreme ultraviolet images of the solar disk. This information is used to study the effects of solar radiation on the temperature and composition of the atmosphere.

The mission also carried a series of smaller scientific experiments in Atlantis' middeck lockers relating to protein crystals, rodent studies, space tissue loss, vapour diffusion, space acceleration measurements and heat pipe performance. ■

STS-63

Rendezvous Success After Discovery Leak Hitch

Discovery was launched on its eight-day mission with NASA's first female pilot and a Russian cosmonaut on board at 12:22 am (0522 GMT) on 3 February after a 24-hour delay due to problems with a navigational unit that had to be replaced. Shortly after the spacecraft reached orbit, however, two of its 38 steering jets failed, with one of them leaking slightly and jeopardising a programmed rendezvous with the Mir space station.

The rendezvous at some 392 km above the Earth would allow the astronauts to photograph the space station from all angles in preparation for an actual space shuttle docking in June. The mission also included spacewalks by two astronauts, scientific experiments and the deployment and retrieval of an astronomical satellite.

Space shuttle Discovery continued however to close in on Mir in anticipation of the planned rendezvous while on the ground, flight controllers assessed plans for the closing-in manoeuvres with the leaking thruster. By now the thruster's oxidiser supply line has been closed and Discovery had been manoeuvred to a nose-toward-the-Sun attitude to warm the thruster. Discovery was expected to catch up with Mir on 6 February and the original plan called for an approach to within 33 feet, but because of the leaking thruster, controllers also looked at back-up plans to change the distance to 400 feet.

In the final decision, Discovery's crew was given the go-ahead to fly within 35 feet as long as the fuel line to the leak was kept closed.

As Discovery edged slowly under Mir, preparing to swoop in front of it, Commander James Wetherbee took manual control and monitored progress not only by looking out of an overhead window at Mir, but also by watching a computer screen that showed the imaginary "tunnel" in space through which he would have to approach Mir if he intended to complete the docking. Pilot Eileen M. Collins called out distances and other data, keeping track of various navigation systems as Discovery approached Mir at a rate of 0.1 feet per second.

The Mir crew had positioned their spacecraft so that its red docking target was facing the approaching shuttle, which flew with its open cargo bay toward the space station. The rendezvous was designed in part to test the shuttle's handling characteristics on the docking approach and to inspect the Mir docking target, in preparation for a planned shuttle docking in June. Shortly after 1 pm, Discovery's path finally intersected that of Mir at a point directly in front of the Russian space. At a distance of 1,000 feet it went into a special flight mode in which it used only jets not pointing directly at Mir, in order to avoid contaminating Mir with



The shuttle programme's first female pilot Eileen M. Collins is seen, above right, in training as a 1990 candidate astronaut, and in the above photo in training with commander James Wetherbee at JSC in November 1994.

NASA

jet gases.

At 1:30 pm, Wetherbee received the final go-ahead for a close approach. Ten minutes later, as the two craft passed into darkness over Africa, he began to slowly decrease the gap between the vehicles. At about 2:20 pm, just after the two vehicles moved back into daylight over the Pacific, he inched in to a distance of 37 feet and the two craft hovered at about that range for 10 minutes. After backing away from Mir, Wetherbee flew one and a half times around Mir, concluding the rendezvous at about 4:30 pm.

A detailed account of the mission will appear in a forthcoming issue.

'M' for 'Mobile'

Inmarsat Renamed

Inmarsat's plans to launch a global handheld satellite phone service by the end of the decade have received the unanimous approval of its Assembly of Parties, which represents Inmarsat's 75 member countries.

The Assembly also agreed to change Inmarsat's formal name from the International Maritime Satellite Organization to the International Mobile Satellite Organization. Inmarsat was originally set up 15 years ago to provide commercial and distress and safety communications for the maritime community. It has since evolved to provide mobile satellite communications for aircraft inflight and land mobile users around the world.

Tragically, debris from the falling rocket and payload reportedly killed six people and injured 23 others in sparsely populated villages under the ascent trajectory. The debris impacted the ground just 6.5 km from the launch site. Chinese officials did not immediately reveal the loss of life but later said that rescue work was underway with experts from Beijing on hand. The loss of a second commercial payload may have a great impact on China's attempts to corner a slice of the commercial satellite launcher market although the group owning Apstar said that they would procure and launch a replacement satellite as soon as possible.

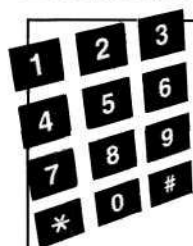
The launch was attended by more than 100 politicians and potential customers.

NEVILLE KIDGER, FBIS

Deaths Follow Launch Disaster in China

A Chinese Long March 2E launch vehicle exploded just over one minute after it was launched from the Xichang launch base in western Sichuan province. The launch was shown live on Chinese TV and the fragmentation could be seen clearly in the clear night sky.

The rocket was launched at 2240 GMT on 25 January (0640 on 26 January in China). The launcher was carrying a Hughes Space and Communications made satellite called Apstar 2 owned by a Hong Kong group. It was China's second commercial launch failure following the much-disputed loss of the Optus-B satellite in December 1992 from the same site.



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Mission STS-72

Spacewalks to Aid Station Assembly

A crew of six under the command of US Air Force Colonel Brian Duffy will be launched in December on Space Shuttle mission STS-72 to retrieve a satellite, deploy and retrieve another, and conduct two spacewalks.

Also on the nine-day flight are Navy Lieutenant Commander Brent W. Jett, Jr., pilot, and mission specialists Leroy Chiao, Daniel T. Barry, Navy Commander Winston E. Scott and Japanese National Space Development Agency (NASDA) mission specialist, Koichi Wakata.

STS-72 mission objectives include retrieval of an octagonally shaped science satellite the Space Flyer Unit (SFU) carrying 14 experiments that is scheduled to be launched aboard a Japanese H-2 rocket in early 1995.

In addition to the SFU retrieval, the crew will use the Shuttle's robot arm to deploy and retrieve another science satellite, the Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN). This multi-use spacecraft flies free of the Shuttle for several days, gathering astronomical data prior to its retrieval.

Also during the flight, Chiao and Barry will conduct two spacewalks designed to evaluate assembly requirements and techniques for the International Space Station.

Order Placed for Space Station

On 13 January, NASA and Boeing Defense and Space Group, Missiles and Space Division, of Houston, Texas completed negotiations and signed a \$5.63 billion contract for the design and development of the International Space Station. The contract, which extends to June 2003, is a cost-plus-incentive-fee and award-fee agreement.

Assembly will begin in November 1997 with the launch of the US purchased Russian FGB power and propulsion module. It will be followed by the launch of the US Lab Module in November 1998, the Canadian robotic arm in December 1998, the Japanese Experiment Module in March 2000 and the European Columbus Orbital Facility in February 2001. Assembly is scheduled to be completed in June 2002.

Canadian Robotics for Space Station

Spar Aerospace Limited has received a \$2.7 million increase to its contract for the Japanese Experiment Module End Effector programme for Japan's contribution to the International Space Station.

The contract relates to areas of interface design, enhancement of performance and supply of additional hardware, and brings the total value of the contract awarded to Spar by Toshiba Corporation of Japan in April 1993 to \$23 million.

The end effector, or hand of the robot, was developed by Spar for the Canadarm and will be modified for use on the International Space Station. Spar is developing two robots for the International Space Station, the Space Station Remote Manipulator System and the Special Purpose Dexterous Manipulator.

Spaceflight Crossword

No. 19

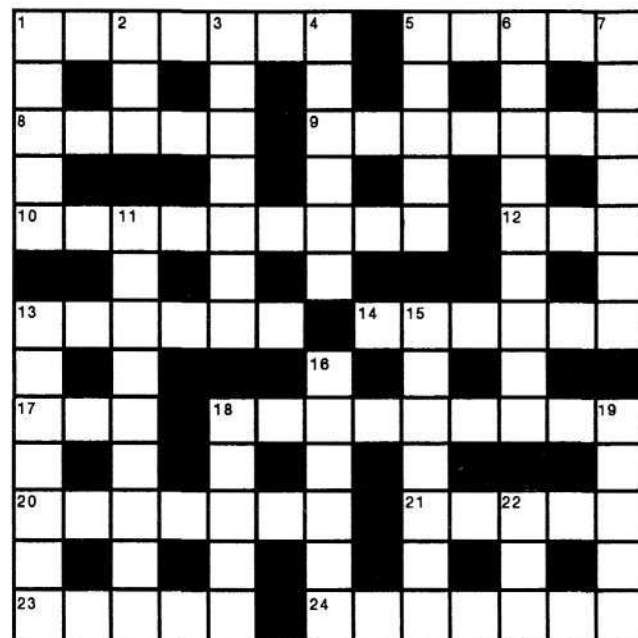
ACROSS

1. Satellite of Uranus
5. Liquid perfectly neutral in reaction
8. Zenith's opposite point
9. Direction finder
10. Absorption of 5. Across
12. Colloidal suspension in a liquid
13. One of many found on the Moon
14. Struggled
17. Gemini spacecraft astronauts, for example
18. First person to observe dark lines in the solar spectrum
20. Injurious to health
21. Construction from which spectators view a launch
23. Follow
24. Visual

DOWN

1. Non SI unit of time
2. The — Planet
3. Tell sequence of events
4. Great Bear territory
5. Female
6. Convey
7. Determine
11. Meteor shower associated with Pons-Winnecke's comet
13. Rhythm
15. Passage of a star over the meridian
16. Proportion of incident light reflected by a planet
18. Complete
19. Pertaining to the intersection of a planet's orbit and the ecliptic
22. Part of a curved flight path

Solution will appear in the April issue.



Solution to Crossword No.18.

ACROSS: 1. Lander; 2. Probe; 8. Nagel; 9. Laplace; 10. Twelves; 11. Feet; 12. Ham; 14. Stun; 15. Inch; 18. Sun; 21. Rake; 23. Orchard; 25. Arabsat; 26. Engle; 27. Enter; 28. Closest.

DOWN: 1. Length; 2. Neglect; 3. Enlivens; 4. Pipe; 5. Orate; 6. Elects; 7. Clash; 13. Mitchell; 16. Charges; 17. Ariane; 19. North; 20. Advent; 22. Kvant; 24. User.

Manned Space Flights

A crowded 1995 calendar includes the docking with Mir of three manned Soyuz-TM capsules and two US Space shuttle missions out of a total of eight shuttle missions, the first of which was STS-63 launched on 3 February. Dates are subject to change. Names in brackets are back-ups.



Crew members for the joint Shuttle/Mir missions during three weeks of training at JSC in June 1994. Front row (left to right) Norman E. Thagard, Vladimir N. Dezhurov and Gennady M. Strekalov. Back row (left to right) Yuri I. Onufrienko, Anatoly Y. Solovyov, Bonnie J. Dunbar, Nikolai M. Budarin and Alexander F. Poleshchuk. NASA

March 1995

- 02 **Launch:** STS-67/Endeavour. ASTRO-2 mission.

Crew: S. Oswald, W. Gregory, T. Jernigan, W. Lawrence, J. Grunsfeld, S. Durrance (S. Vangen) and R. Parise (S. Vangen).

- 14 **Launch:** Soyuz TM-21.

Crew: V. Dezhurov (A. Solovyov), G. Strekalov (N. Budarin) and N. Thagard (B. Dunbar) (EO-18 Expedition).

- 18 **Landing:** STS-67/Endeavour.

- 26 **Landing:** Soyuz TM-20.

With: A. Viktorenko, E. Kondakova and V. Polyakov (EO-17 expedition).

June

- 10* **Launch:** STS-71/Atlantis. First Shuttle/Mir docking mission, delivery of the Mir EO-19 expedition (Solovyov/Budarin).

Crew: R. Gibson, C. Precourt, B. Dunbar, E. Baker, G. Harbaugh, A. Solovyov (Y. Onufrienko), and N. Budarin (A. Poleshchuk).

- 17 **Landing:** STS-71/Atlantis

With: the American crew and V. Dezhurov, G. Strekalov and N. Thagard (EO-18 expedition).

- 22 **Launch:** STS-70/Discovery. Mission to deliver the TDRS-G satellite.

Crew: T. Henricks, K. Kregel, N. Sherlock, D. Thomas and M. Weber.

- 27 **Landing:** STS-70/Discovery.

July

- 20 **Launch:** STS-69/Endeavour. Mission to experiment with the Wake Shield Facility.

Crew: D. Walker, K. Cockrell, J. Voss, J. Newman and M. Gernhardt.

- 30 **Landing:** STS-69/Endeavour.

August

- 22 **Launch:** Soyuz TM-22

Crew: Y. Gidzenko (G. Manakov), S.

Avdeyev (S. Treshchev) and ESA representative K. Fuglesang (T. Reiter or vice versa) (EO-20 expedition).

September

- 21 **Launch:** STS-73/Columbia. USML-2 mission.

Crew: K. Bowersox, K. Rominger, K. Thornton, C. Coleman, M. Lopez-Alegria, A. Sacco (D. Matthiessen), F. Leslie (G. Holt).

October

- 07 **Landing:** STS-73/Columbia.

- 26 **Launch:** STS-74/Atlantis. Second Shuttle/Mir docking flight.

Crew: K. Cameron, J. Halsell, J. Ross, W. McArthur and C. Hadfield.

November

- 01 **Landing:** STS-74 Atlantis.

- 30 **Launch:** STS-72/Endeavour. Mission to retrieve the Japanese free flying microgravity research laboratory SFU. **Crew:** B. Duffy, B. Jett, L. Chiao, D. Barry, W. Scott and NASDA representative K. Wakata.

December

- 08 **Landing:** STS-72/Endeavour

- 25 **Launch:** Soyuz TM-23.

Crew: Y. Onufrienko (V. Tsibliyev) and A. Poleshchuk (A. Lazutkin) (EO-21 expedition). In March 1996 the EO-21 crew will be enlarged by a NASA astronaut, J. Blaha or S. Lucid. The NASA-astronaut will travel to Mir aboard STS-76, the third Shuttle/Mir docking flight.

January 1996

- 04 **Landing:** Soyuz TM-22.

With: Y. Gidzenko, S. Avdeyev and the ESA representative, Fuglesang or Reiter (EO-20 expedition).

1995 Astronaut Candidates

On 8 December 1994, 19 new astronaut candidates were selected for the Space Shuttle programme. The 1995 group consists of 10 pilots and 9 mission specialists, including 6 civilians and 13 military officers.

The candidates were chosen from among 2,962 applicants and NASA brought 122 of the applicants to the Johnson Space Center, Houston, for interviews and medical evaluations. The candidates will report to Johnson in March 1995 to begin a year of training and evaluation, followed by technical assignments within the Astronaut Office to prepare them for assignment to Shuttle flight crews.

The 1995 Astronaut Candidate class is also to include international participants and, on 13 January, it was announced that Japanese astronaut Takao Doi of NASDA and Canadian astronaut David S. Williams of the Canadian Space Agency had been selected.

NASA's Medium Light Programme

On 7 December 1994, McDonnell Douglas and Orbital Sciences joined forces to pursue as a team NASA's Medium Light (Med-Lite) Expendable Launch Vehicle Services programme.

NASA seeks to procure a new class of launch services to fill the gap between the small launch vehicle market (3,000 pounds to low-Earth orbit), primarily served by Orbital's Pegasus and Taurus space launch vehicles, and the medium-class market (10,000 pounds to low Earth orbit), primarily served by McDonnell Douglas' Delta II rocket. The chief requirement of the Med-Lite programme is to support the future Mars Surveyor and Discovery programmes.

Good Start to 1995 for Intelsat

On 10 January 1995, Intelsat began an aggressive campaign to put additional capacity in orbit with the successful launch of its Intelsat 704 spacecraft aboard a Martin Marietta Commercial Launch Services Atlas IAS launch vehicle from Cape Canaveral, Florida.

The satellite is the first of the new, high-powered Intelsat VII series to be deployed to the Indian ocean Region and will be located at 66°E.

Launch Insurance Record

Intelsat has concluded the largest placement for satellite launch insurance ever undertaken in the industry. The total value of the satellite and launch vehicle costs being insured is nearly US\$2 billion and provides insurance for the launch phase (before separation of the satellite from the launch vehicle) for ten Intelsat launches which are due to take place between 1995 and 1997. Seven of the launches will be for Intelsat spacecraft launched by Ariane and three for Intelsat spacecraft launched by Long March. The insurance premium being paid by Intelsat is approximately US\$185 million.

* This mission is currently targeted for the last week of May and the first week of June.

In addition to this schedule the final two modules for Mir (the Spektr and Priroda laboratories) will be launched respectively on 10 May and 10 November 1995. Also five Progress-M cargo vehicles, Progress M-27 to Progress M-31 will be launched on 5 April, 21 June, 18 July, 6 September and 22 November 1995. Various EVAs will be carried out as well by Russian and American crew members.

ANNE van den BERG, FIBS

SATELLITE DIGEST-274

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Launch Date	Launch Site	Launch Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
PanAmSat 3	None	Dec 1.96	Kourou	Ariane 42P	2,985	Failed to reach orbit					[1]
Molniya-1 88	1994-081A	Dec 14.60	Plesetsk	Molniya-M	1,600 ?	Dec 31.72	62.78	717.69	441	39,910	[2]
Luch 1	1994-082A	Dec 16.50	Tyuratam	Proton-4	2,300 ?	Dec 21.43	2.58	1,436.01	35,755	35,815	[3]
Cosmos 2298	1994-083A	Dec 20.22	Plesetsk	Cosmos	900 ?	Dec 20.27	74.03	100.83	786	810	[4]
DSP 17	1994-084A	Dec 22.93	ER	Titan-4/US	2,360	Geosynchronous orbit					[5]
Radio Rostov	1994-085A	Dec 26.13	Tyuratam	Rokot	70	Dec 27.79	64.80	128.66	1,875	2,253	[6]
Cosmos 2299	1994-086A	Dec 28.35	Plesetsk	Tsyklon	225 ?	Dec 28.35	82.57	113.97	1,402	1,416	[7]
Cosmos 2300	1994-086B				225 ?	Dec 28.35	82.57	114.05	1,409	1,416	
Cosmos 2301	1994-086C				225 ?	Dec 28.35	82.58	114.11	1,412	1,418	
Cosmos 2302	1994-086D				225 ?	Dec 28.35	82.57	114.20	1,414	1,423	
Cosmos 2303	1994-086E				225 ?	Dec 28.35	82.58	114.26	1,415	1,429	
Cosmos 2304	1994-086F				225 ?	Dec 29.54	82.57	114.11	1,411	1,419	
Raduga 32	1994-087A	Dec 28.48	Tyuratam	Proton-4	2,000 ?	Dec 30.69	1.50	1,439.24	35,796	35,900	[8]
Cosmos 2305	1994-088A	Dec 29.48	Tyuratam	Soyuz	7,000 ?	Dec 30.28	64.91	89.89	240	298	[9]
NOAA 14	1994-089A	Dec 30.42	WR	Atlas-E	1,712	Dec 30.46	98.90	102.05	848	863	[10]

NOTES

- PanAmSat 3 was a telecommunications and TV programmes transmission satellite, built by Hughes Space & Communications for PanAmSat in Greenwich, Connecticut (USA). Spacecraft failed to reach orbit following a malfunction during the Ariane's third stage burn. The enquiry board reported that inadequate thrust was obtained from the third stage engine because of less-than-normal pressure in the gas generator; in turn this was due to an insufficient supply of oxygen to the gas generator. This was the first use of the new H-10-3 third stage.
- Communications satellite; launch announcement identified this as the 48th flight of the "Molniya-1T" series, although it is unclear whether this count includes launch failures.
- Data relay satellite in the SDRN system, performing a similar mission as the United States TDRS. Previous launches have been within the Cosmos programme; Luch 1 is located over 95°E.
- Believed to be a military store-dump communications satellite.
- Defense Support Program satellite launched to monitor nuclear explosions. No orbital data were released for the mission.
- Amateur radio satellite, designated RS-15; first orbital flight of the Rokot, derived from the RS-18 (SS-19) missile.
- Six second generation military field communications satellites.
- Military communications satellite, to be located over 70°E.
- Fifth generation photoreconnaissance satellite. Launched to replace Cosmos 2267 (1993-071A) which had been recovered on December 28 after operating at 70.4°; Cosmos 2280 (1994-025A) also at 70.4° remains in orbit.
- NOAA 14 (NOAA J before launch) is a meteorological satellite built by Martin Marietta Astro Space and replacing NOAA 13 (1993-050A) which suffered a power failure shortly after launch.

1989-033B Magellan decayed in the atmosphere of Venus October 12; the decay of this spacecraft has not been listed by USSPACECOM, presumably because the spacecraft is still "in space", in the sense that it has not returned to Earth.

1993-018A Cosmos 2238 decayed from orbit December 9.

1993-071A Cosmos 2267 was de-orbited December 28. This gives a lifetime of 419 days, the longest for this class of satellite.

1994-036A The undocking of Soyuz-TM 19 reported with the November launch listing issue took place on November 2, not November 3rd as quoted.

1994-040A PANAMSAT 2 was boosted off-station over 194-195°E during August 8 - August 10 and by September 13 it had been relocated over 168-169°E.

1994-043A APSTAR 1 was relocated over 130-131°E approximately August 10. During September 6 - September 8 the satellite was boosted off-station and during September 11 - September 13 it was relocated over 137-138°E.

1994-047A DBS 2 was initially deployed over 257°E after drifting slowly until the end of August 1994.

1994-055A Optus-B 3 was initially located over 152°E approximately September 7. Add the following orbital data: Sep 28.18, 0.76°, 1,436.01 minutes, 35,646 km, 35,923 km.

1994-069A Elektro 1 has had its orbit stabilised over 75-76°E: USSPACECOM data previously reported and suggesting that the satellite was drifting over 45°E was in error. Add the following orbital data: December 9.69, 1.18°, 1,435.93 minutes, 35,772 km, 35,794 km.

1994-076A Add the following orbital data for Cosmos 2294: December 7.28, 64.89°, 675.75 minutes, 19,052 km, 19,208 km.

1994-076B Add the following orbital data for Cosmos 2295: December 9.80, 64.88°, 675.74 minutes, 19,099 km, 19,161 km.

1994-079A Add the following orbital data for Orion 1: December 14.23, 0.03°, 1,437.85 mins, 35,621 km, 36,021 km.

1994-080A Navigation problems prevented the scheduled geosynchronous orbit injection of DFH-3 1 in early December. At the end of December the satellite had been placed in a geosynchronous drift orbit. Add the following orbital data: December 13.58, 12.43°, 760.79 minutes, 6,391 km, 36,065 km December 29.38, 0.26°, 1,425.91 mins, 35,181 km, 35,993 km.

ADDITIONS AND UPDATES

- 1983-077A Telstar 301 was manoeuvred off-station over 252-253°E during August 3 - August 6 and has been drifting ever since; presumably it has been retired. Add the following post-manoeuve orbital data: 1994 Aug 7.21, 0.69°, 1,432.77 minutes, 35,718 km, 35,725 km.
- 1984-029A Molniya-1 60 decayed from orbit November 4.
- 1985-087A Between September 18 - September 18 INTELSAT 501 was relocated from 358°E to 338°E.
- 1986-026B During October 1994 BRASISAT A2 appears to have been relocated from 290°E to 295°E.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

8 March 1995

7 - 8.30 pm

Missions to Mercury

Future Study Possibilities for the Innermost Planet

Prof G.H.A. Cole
University of Hull

Over a period of ~28 months, the Mariner 10 spacecraft made a series of three fly-by encounters with Mercury. A surprising result was the detection of a dipole magnetic field with a probable strength of 1% of that of the Earth's. The importance of Mercury in the study of the Solar System has now led to further missions to Mercury coming under consideration in NASA, ESA and elsewhere. In this lecture Professor Cole will review current knowledge and will be discussing the scientific aims and the options available for the study of Mercury by proposed and possible future missions to the innermost planet.

Elections to Council

The Report of the Scrutineers on the ballot papers counted up to and including 31 January 1995 was as follows:

Number of papers received were 617, none of which were rejected for late arrival. There were no spoilt Papers.

The names of the candidates and the number of votes cast for each was as follows:

Position	Name	No of Votes
1.	D.E.B. Wilkins	565
2.	C.M. Hempell	552
3.	G.E. Hunt	524
4.	M.R. Fry	504
5.	R.A. Buckland	211

The four candidates receiving the highest number of votes and who were accordingly declared elected were:

D.E.B. Wilkins	C.M. Hempell
G.E. Hunt	M.R. Fry

5 April 1995

7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack
Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Colin Jack will be discussing cheaper proposals, and trying to pick some winners. Suggestions from the floor, please!

3 May 1995

7 - 8.30 pm

The Design, Instrumentation and Function of the Cassini Mission Titan Surface Probe (Huygens Lander)

Dr John Zarnecki
University of Kent

The mission will be described with emphasis on ESA's contribution, the Huygens Probe, which will land on the surface of Saturn's largest moon Titan.

SYMPOSIA

26 April 1995

10 - 4.30 pm

Electronics in Space

Major advances in electronics in recent years have had an enormous impact on spacecraft design and on what can be accomplished in space within a given mass and volume. This one-day symposium will cover some of the more important developments in this field, such as the use of microprocessors, transputers and highly efficient switched-mode power supplies. It will also include the latest information concerning the effects of the space environment on advanced electronics systems. Some of the themes will be:

- The radiation environment and its effects on electronics systems
- The selection of components, with emphasis on minimising cost
- Space qualification principles, methods and results
- Transputers and their use in on-board computers
- Design principles for power systems
- Design principles for science instruments
- The STRV on-board computer and data handling system
- Electronics for low-cost imaging systems
- The power conditions and control equipment for the UK-10 ion propulsion system

Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

3 June 1995

10 - 4.30 pm

Soviet/CIS Astronautics

The Soviet/CIS symposium is acknowledged as one of the foremost meetings for the presentation of material on current and historical reviews of the space programmes of the Soviet Union and its successor Republics. The meeting attracts Fellows, members and other leading experts from Europe and the United States. Many of the papers are reproduced in *Spaceflight* and *JBIS* Soviet Astronautics issues.

Papers already offered for the next symposium include the current NASA-Russian Cooperation Programme, a review of the politics of the Soviet Space Programme in the 60s and important papers on one of the Soviets' unmanned programmes.

Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers on other topics of interest to the Society are invited. Please send details to the Executive Secretary.

13 September 1995

10 - 4.30 pm

Low-Cost Satellites

In response to a general concern about the escalating expense of space missions, many organisations have been attempting to reduce costs substantially, primarily by the innovative design of micro- and mini-satellites. In this context, advanced technologies and new project management techniques have had a major impact on what can be achieved with smaller masses and volumes, and thus with less costly launch vehicles. Some of the topics relevant to this theme will be:

- The low-cost approach to the design and construction of spacecraft
- Lessons from the design, development, construction, launch and operation of the UoSAT satellites
- The STRV spacecraft: platform design overview and flight experience
- The STRV spacecraft: an overview of experimental results
- The SIL spacecraft designs and associated technologies
- The application of low-cost spacecraft to science missions
- Low-cost interplanetary applications using ion propulsion
- The UoSAT mini-satellite concept
- The ARGOS high energy upper stage: a way of augmenting the limited capabilities of small launchers

Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

JBIS



The March 1995 issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

General Issue

Magellan Aerobrake Navigation

The Hypersonic Skyhook

A Low-Cost Propulsion Option for Small Satellites

The ENVISAT-1 Ground Segment

The Ulysses Data System

Anisotropies in the Low Altitude Radiation Environment

New Technologies for Supporting Real-Time On-Board Software Development

Copies of JBIS, priced at £5.00 (US\$9.00) to members, £17.50 (US\$32.00) to non-members, post included, can be obtained from the address below. Back issues are also available.

The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ England.

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The International Magazine of Space and Astronautics

EXPLOSION IN SPACE

**25th
Anniversary of
Apollo 13
Drama**

**The Crew that
Made it Home**



**SPACE TECHNOLOGY
New Roles Revealed**

**SHUTTLE-MIR
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04

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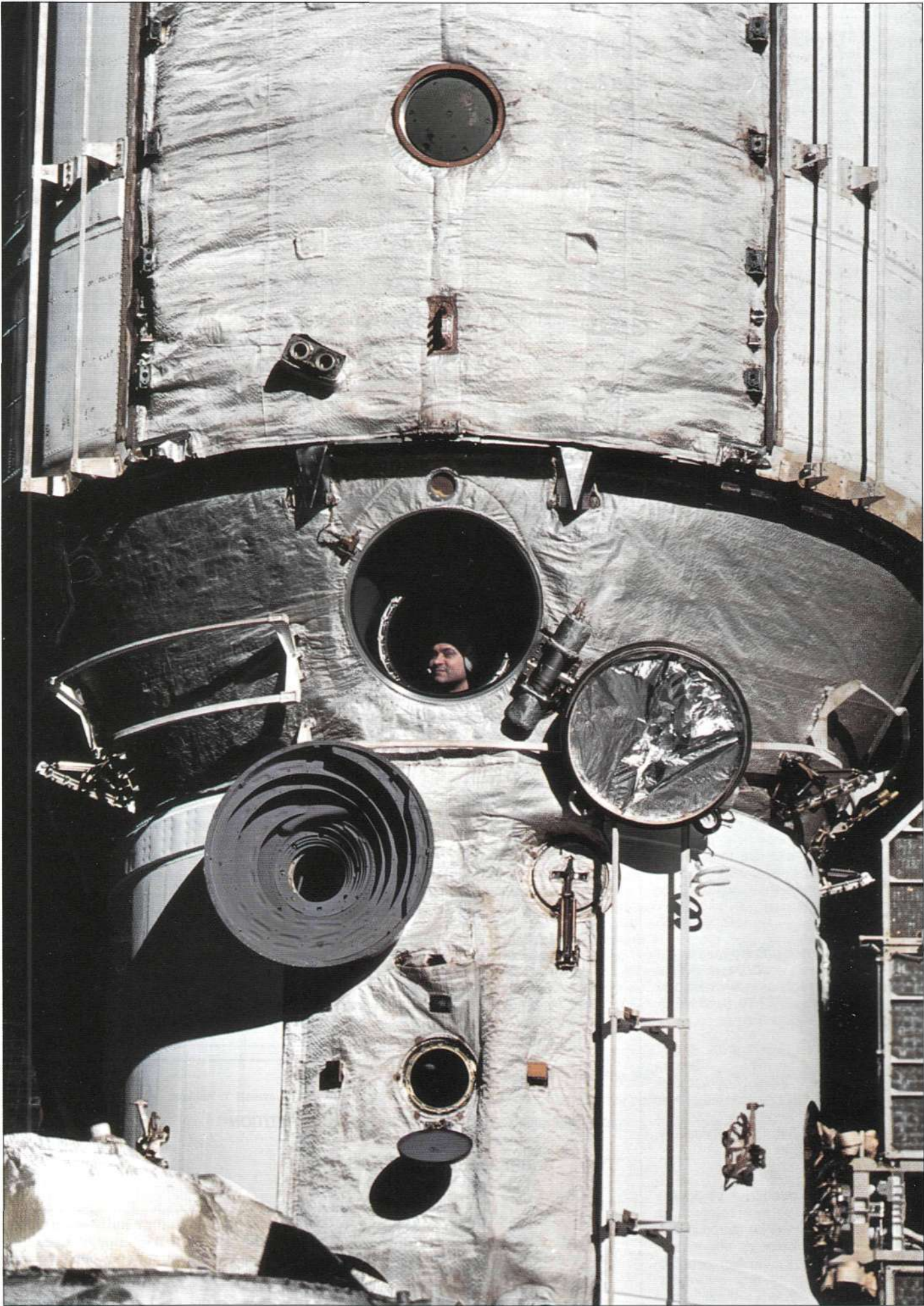
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Front Cover: View of the Moon from Apollo 13. On 14 April 1970 the crippled spacecraft passed behind the Moon and rookie-astronauts Haise and Swigert set about shooting pictures, much to the amazement of their veteran commander! A final minor problem on Apollo 13 was that the original official crew picture had been made obsolete by Mattingly's last-minute replacement. Only after their return to Houston did the crew get a chance to have a new portrait taken, this time with Jack Swigert in the middle. See p.126 for the full story by Ed Hengeveld, courtesy of whom the front cover material is supplied. NASA



Cosmonaut Valeri Polyakov, who boarded Mir on 8 January 1994, looks out of a Mir window during rendezvous operations.

NASA

Meeting in Space: 6 February 1995

Shuttle-Mir Spectacular

On 6 February 1995 the Russian space station Mir was joined in orbit by the American Space Shuttle orbiter Discovery during an historic encounter.

Joint Activities

The rendezvous of the two nations' spacecraft was a prelude to a period of cooperation set to begin properly with the launch on 14 March of American Dr Norman Thagard with Russians Vladimir Dezhurov and Gennadi Strekalov to man the space station for the next three months as its 18th main crew (EO-18).

The three cosmonauts will return on the Space Shuttle orbiter Atlantis in June 1995 following the first docking between American and Russian/Soviet craft since the 1975 Soyuz-Apollo mission.

Dezhurov will ceremonially welcome shuttle commander Robert "Hoot" Gibson at the entrance to the Kristall module at which the orbiter Atlantis, equipped with a Russian made unit, will dock. Atlantis will deliver the EO-19 crew of Anatoli Solovyov and Nikolai Budarin. Thagard's back-up, Dr Bonnie Dunbar, will be on the flight but will not stay on the complex.

The American agreement to join the Mir project will see long-duration flights of astronauts on the complex and up to seven dockings and crew rotations using the American shuttle orbiter fleet. The next American on Mir for a long duration visit will be either John Blaha or Shannon Lucid who will be launched at the year's end on a Soyuz as a part of the EO-21 crew.

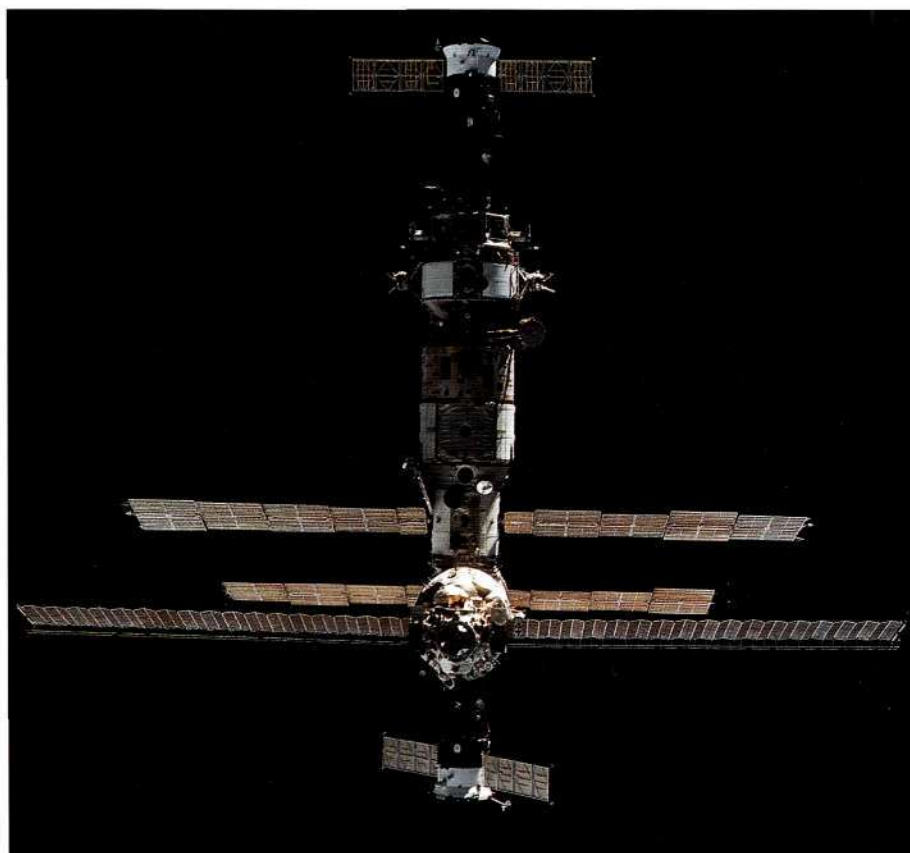
The Russians will continue to maintain the Mir with unmanned cargo spacecraft and will complete the assembly of the complex with the final two specialised modules to dock with it in May and November 1995.

In addition there will be a number of EVAs in April and May to move the Kristall module's solar arrays and install a new docking unit. Thagard may be involved as an active participant in these EVAs.

Before these events could begin however, there was to be the scheduled visit of the orbiter Discovery to the complex where cosmonauts Aleksandr Viktorenko, Yelena Kondakova and Dr Valeri Polyakov are already in the fourth month of their stay as the 17th main expedition and are scheduled to return to Earth on 26 March.

Rendezvous Plans

The Space Shuttle orbiter Discovery was launched into space from the Kennedy Space Centre in Florida a day behind schedule at 0522.04 GMT



Mir during rendezvous operations on 6 February 1995.

NASA

BY NEVILLE KIDGER, FBIS

Leeds, UK

on 3 February. The one day delay was caused by the need to change one of the orbiter's inertial measurement units which failed the previous day before loading of the fuel had commenced.

Amongst the six member crew of the orbiter was Russian cosmonaut Vladimir Titov who had already conducted an almost 366 day mission to the Mir station between December 1987 and December 1988 with engineer Musa Manarov.

One of his visitors during that year-long mission was a rookie cosmonaut called Aleksandr Viktorenko. Now, with Viktorenko on his fourth stay on the Mir complex, Titov was to be the short-term visitor but without crossing into the complex.

Initial plans had called for a pass of the American orbiter at a distance of about 100 m but that distance had contracted as the plans advanced.

After long negotiations between the Americans and Russians the separation distance was reduced to just 10 m. One American document said that an approach of 30 ft had been agreed but the Russian side stuck rigidly to the 10 m (32.8 ft) separation. In the end the Americans agreed on

35 ft as the optimal minimum approach distance. The Russian reluctance to allow the orbiter closer was based upon the desire to avoid a collision between the two massive craft. The American side was responsible for collision avoidance during the approach whilst the NPO Energiya, owner and operator of the complex, held the responsibility for the prevention of unexpected linear manoeuvres from the complex.

Discovery would approach the Kristall docking port using a TV camera mounted in a porthole atop the Spacehab module located in the orbiter's payload bay. The actual docking in June will use a boresighted camera located in the Russian-made docking assembly. The shuttle commander, in this case James Wetherbee, was to use the TV pictures as a guide for the approach whilst controlling the orbiter from the aft flight deck station.

In addition, for the Discovery rendezvous and flyby, communications with the crew of the Mir were to be maintained via a VHF hand-held communications set by Vladimir Titov. The Russians said that in the event that the Mir complex was to lose orientation during the rendezvous the orbiter was to move away to a distance of 75 m pending another approach attempt.

Damage Possibility

It should be remembered that the Mir complex was twice involved in collisions in 1994 by a manned Soyuz (January) and a Progress M cargo ship (August). These collisions led to only minor damage to the Kristall vacuum insulation. However the consequences of a collision between the 90 + tonne complex and a 100 tonne orbiter would lead to graver consequences.

Before the crew of Discovery had a chance to settle down to orbital life there was word that the closest approach was in danger of being cancelled. The problem lay in one of the orbiter's small reaction control system thruster jets, RU1, located at the right rear of the orbiter which sprang a leak of nitrogen tetroxide oxidizer as soon as the craft reached orbit. A second thruster began leaking shortly afterwards but was soon isolated and posed no threat but the rear thruster, one of a linked set vital for manoeuvres continued to leak at a small rate throughout the first three days of the Discovery flight.

Initial reports said that NASA was planning to restrict the orbiter's approach to a minimum of 120 m (400 ft). Shuttle Mission Director Randy Stone told reporters that he was asking himself how he would react if he were on the Russian side. He concluded that he would do as they were doing.

NASA and NPO Energiya officials began protracted negotiations regarding the problem and its possible solutions taking account of contingencies governing the rules for the approach. The thruster leak was thought to have been caused by a block of ice preventing a valve from closing properly. A similar problem with the forward thruster was resolved by heating the area by pointing the orbiter's nose to the Sun for several orbits and closing the manifold to allow pressure to build up and dislodge the blockage. However, this technique failed to clear the recalcitrant rear thruster leak.

In an attempt to stop the leak shuttle commander Wetherbee and pilot Eileen Collins closed and re-opened the manifold of the leaky rear thruster several times but still the oxidizer leaked. In TV pictures the leak was reminiscent of a geyser although in reality it was several times smaller. The rate of leakage decreased from 2 lb per hour to a quarter of that but it was still a problem. The manifold was closed before the crew went to sleep on 5 February, the night before the historic rendezvous was due.

From information presented to the press the Russian concern lay not primarily with the impact the debris would have on the solar arrays of the Mir complex but rather with the possibility that the cloud of ice particles could damage or obstruct the performance of the optical and IR sensors of the Soyuz TM-20 spacecraft

needed for the return of the crew in March.

Speaking to the press from space Collins said that even if the close approach was cancelled the Americans would learn much about the performance of navigation, communications and flying skills applicable for the docking missions.

But Wetherbee was obviously disappointed that the close approach could be cancelled. All rested on the intense negotiations underway in Houston and Kaliningrad. Randy Stone described the Russian approach as "very methodical and conservative" as they sought to understand the American orbiter's capabilities. Stone ventured that one solution was to shut down the block of three thrusters of which one was the leaker. However this would still mean no close approach.

Speaking later, NASA's Frank Culbertson who was at the Kaliningrad TsUP as part of the US delegation, said that the two sides had, throughout the 3½ days of negotiations, learned how to present information to the other side in an orderly fashion so that the mission managers and officials could appreciate all facets of the problem.

Discovery Flyby

Discovery's crew awoke some 13 hours prior to the planned time of rendezvous with still no word from the ground and about 1,500 km away from Mir. The first critical manoeuvre for the approach was at 1416 GMT when Discovery's engines were lit. Another firing at 1502 GMT decreased the rate at which the orbiter closed on the station.

At 1525 GMT CAPCOM Story Musgrave at the MCC in Houston radioed to tell Wetherbee that, subject to three conditions, the go-ahead had been received for the 10 m close approach. The shuttle commander radioed back to say a hearty "thank you" to the teams from Russia and the US who had worked on the issue.

The conditions were that the right thruster manifold was closed and shown to have stopped leaking prior to 300 m from Mir; that if any one of six critical thrusters failed the approach would be halted; and that Discovery approached no closer than 10 m.

By the time the decision was relayed to the orbiter crew from Houston they apparently were aware because Titov had begun conversing with the Mir crew via the VHF radio at a distance of about 167 km. Titov and the Mir crew spoke in animated fashion throughout the rendezvous. Wetherbee reported, some 5 hours before the final approach, that Titov had seen the station: "That old eagle-eyes thinks he may have seen Mir." Mir appeared to the Shuttle crew as a bright star which they began tracking. The final rendezvous phase began at

1637 GMT with an engine firing which eventually brought the orbiter to a point just 120 m in front of the Mir complex facing the Kristall module.

Throughout this approach phase the Mir crew returned stunning TV images of the orbiter above the Earth which eventually showed it in front of the Kristall module. At one point Titov could be seen waving to his comrades from the aft flight deck windows. The two space vehicles passed into orbital darkness and viewers were treated to interior scenes of the Mir station as Kondakova peered out of the Mir base block's large window at the floodlit orbiter's payload bay seemingly below her.

Polyakov used a reflective board during this phase and the reflections were easily picked up by the orbiter's black-and-white TV cameras.

The final phase, when Discovery was manoeuvred to within 11.3 m of the Kristall docking port was completed at 1920 GMT.

The Russian and American flags placed atop the Spacehab module could be clearly seen.

Discovery was on its 57th orbit of Earth whilst the Mir base block was on its 51,263rd trip around the Earth. For 10 minutes Discovery and Mir kept station. During this phase Viktorenko described the scene and the event as like being in a "fairy tale" and called the profession of a cosmonaut the "greatest God could give anyone". Wetherbee in Russian and English in an obviously well rehearsed speech said: "We are bringing our spaceships closer together. We are bringing our nations closer together. The next time we approach, we will shake your hand and together we will lead our world into the next millennium."

The shuttle commander described the Mir station as the most beautiful thing he had ever seen in space.

As Wetherbee backed Discovery away from Mir and flew around the complex for the next hour hundreds of photos and video shots were taken to document the aging space complex. Some of the film was taken by an IMAX camera mounted in the orbiter payload bay. The cosmonauts and astronauts reflected upon the sights they had seen and the NASA Administrator Dan Goldin mused that nations which only a few years before had been pointing missiles at each other were now cooperating in space. Later the shuttle crew spoke with President Clinton of the USA and were faxed TV shots of the rendezvous as seen by the Mir crew.

Discovery's mission STS-63 also included extended experiments in the Spacehab-3 facility, deployment and retrieval of the Spartan-204 astronomical satellite and an EVA by Bernard Harris and Michael Foale. (A detailed account of the STS-63 mission will appear in a forthcoming issue.) ■

Technology Transfer and the Space Sector

Technology transfer has progressively become an important activity in the space sector for at least two reasons. Firstly, there exists a growing need for Research and Technology Development programmes to meet the demands of industrial competitiveness. Secondly, the number of non-space sectors concerned with applications of space-derived results and technologies has become large, so that in turn the space sector is benefiting from a broader industrial base.

In the case of Europe, the making of the single market is an obvious incentive for increased transnational co-operation and notably technology transfer, both to and from the space sector. Maximising impact requires an adequate global infrastructure and a strategy which goes beyond the short-term future.

Introduction

Since the end of the cold war, funding for space programmes has come under increased pressure due to reduced political priorities, the global economic downturn, and increased world competition. The space sector can no longer afford to remain as isolated as it used to be: it must integrate itself into the industrial fabric and aim to contribute more directly to the improvement of economic and social welfare; the visibility of spin-offs originating from the space sector must also be increased.

This does not mean reducing the space sector to an appendage of other sectors, nor does it mean leaving out its most fundamental characteristic: the advancement of science. But it does mean finding tangible ways to increase its popularity as a sector of improved overall economic spin-off and impact on industrial competitiveness. Technology transfer is instrumental in the process of finding these ways (Figure 1).

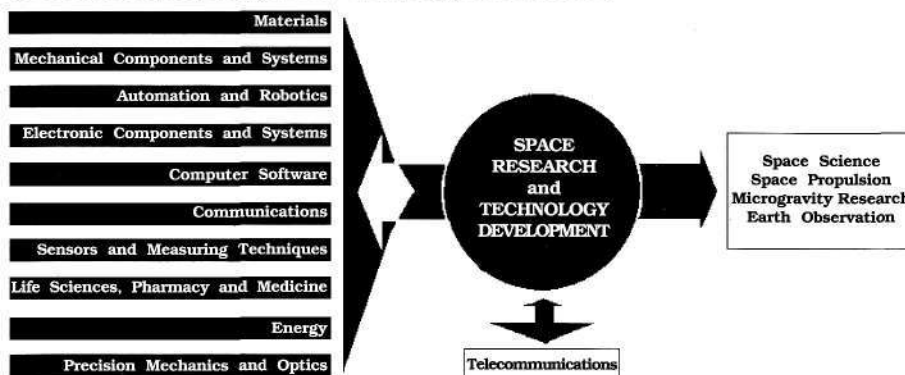
What is Technology Transfer?

Technology is scientific/technical knowledge engineered, i.e. applied for a practical purpose. Technology transfer is any mechanism whereby such practical knowledge is passed from one party to another. This practical knowledge can be embodied in a

Figure 1: Technology transfers from the space sector. This figure illustrates the transfer of technologies between space and non-space industries. The arrows indicate technology transfers, showing, for example, that there are some sectors (e.g. space science and propulsion) where there are no significant transfers to non-space sectors, and others where the relationship is lopsided (telecommunications).

In this field, however, these relationships can change rapidly. Microgravity research, for example, is progressing quickly, and the numerous possible transfers it could yield will be getting a serious boost with the International Space Station planned to orbit the Earth in a few years.

The diagram is, of course, a simplification. In the power and energy conversion sector, for example, battery technologies are transferred to, rather than from, the space sector, while solar cell technologies flow in the opposite direction.



A Short Essay in Innovation Policy

BY DANIEL ROUTIER

Ricardo Hitec Ltd
Luxembourg

piece of hardware or it may be a technique, a process, some know-how, etc. We then talk of transfer of know-how.

Technology transfer is a discipline which can, in due course and ultimately provide the space sector with part of the public and political support it requires for further and meaningful expansion.

The transfer process can be divided into three steps:

- The technology audit phase;
- The marketing phase; and
- The transfer phase itself.

Unfortunately, this simple picture is somewhat misleading. Technology transfer ceases to be a marginal activity only if a number of conditions are fulfilled. These conditions rely on policy considerations and favourable regional and national infrastructures. In the context of the European single market, pan-European infrastructures are also increasingly vital.

Patenting is an important aspect of technology transfer and is closely related to the diffusion of technologies. In many cases, suppliers of technolo-

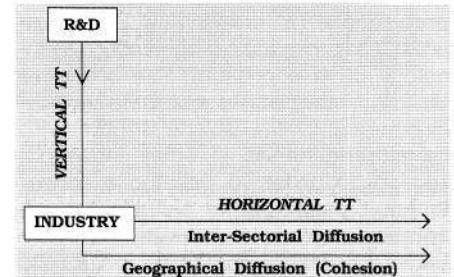


Figure 2: Vertical and Horizontal Technology Transfer (TT).

gies will find much stronger incentive to invest in the transfer process if their product is protected against theft and copying.

Vertical Transfer

The vertical dimension of technology transfer, as a global process (Figure 2), consists in exploitation of research results, or as the French conveniently put it "valorisation". The objective is to bring value to R&D efforts by making results and technologies available to industry, thus setting them on the available markets. Exploitation of research results constitutes an appendix of research, a positive appendix but whose impact on the competitiveness of the industrial fabric is limited. Such activities are often considered as an ex-post justification of research results.

Horizontal Transfer

The horizontal dimension of technology transfer consists in disseminating technologies both across a number of industrial sectors and across national boundaries (Figure 2). This is particularly relevant in the European Union where the markets are fragmented into national or even regional entities and often too small to allow single products to develop competitive advantage. Horizontal technology transfer is a broad activity which covers a number of disciplines just as innovation requires a large number of participating actors.

Promotional Aspects

Space technology can be found in many "day to day technologies" but is rarely identified as such. The problem is one of marketing due in particular to the very long return on investment.

Space is too often considered as a fancy way of spending public money. Efforts should be made to change this

belief by showing the benefits everybody gets in today's life from space-derived technologies. Examples abound: airbags, jogging shoes, satellite communications, tools for the handicapped, software, fire protection material, bra with shape memory metal frame!, etc. The visibility of space technology transfer should be enhanced as part of an image making strategy.

Technology Transfer: A Conceptual Framework

Technology transfer must be tackled proactively (a market oriented approach), rather than reactively (a technology push approach). The proactive strategy attempts to combine emerging needs in the space sector with developing needs in other industrial sectors in order to develop a "core" technological solution suitable for adaptation to various industrial applications. Lateral thinking promotes proactive technology transfer. It consists in a strategy whereby space experts and engineers are active in the exploitation of space-originating technology and its diffusion to other sectors, either directly or following adaptations.

Even when the proactive approach is adopted, technology transfer must fit within the broader context and objectives of an innovation policy. It should be emphasised that innovation must not be mistaken for Research and Development. The concepts are complementary and there can be a great deal of innovation without any specific R&D effort. Research does not systematically lead to innovation.

When research aims at the development of scientific knowledge, innovation policy tends to promote innovation within firms, i.e. the successful commercialisation of new technologies and processes or of a new combination of existing technologies and processes. It therefore directly contributes to the competitiveness of the industrial fabric.

Innovation does not proceed through unidirectional sequences, but is a systems model representing a complex, cumulative and interactive process. Its degree of success, whether originating from the space sector or not, must be complemented by a plethora of services and actors (technical resource centres, public and private financial support, consultant services, other firms, etc.). All these actors constitute the origin of the interactive nature of innovation. (Figure 3). Through the innovation process, the absorptive capacity of firms, and in particular Small and Medium Enterprises (SMEs: less than 500 employees) is enhanced by the quantity and the quality of links with a plethora of private and public actors. SMEs are important because they make up the larger part of the industrial fabric. Basically, improving the absorptive capacity of firms is synony-

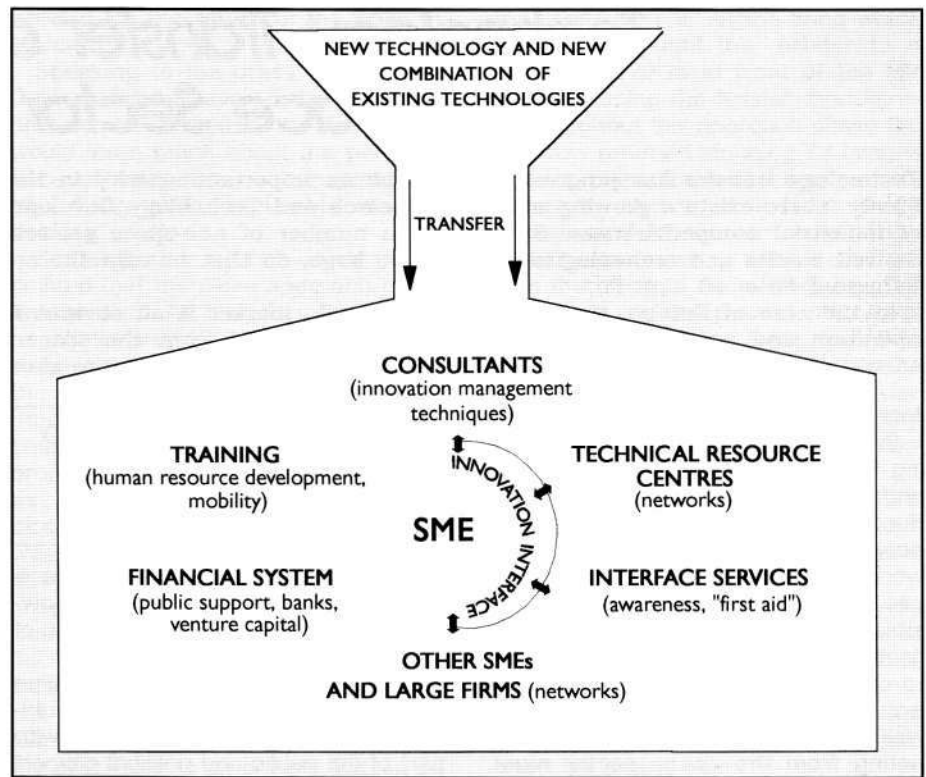


Figure 3: A conceptual framework for innovation showing the "systems model". R&TD in the form of new technologies and a new combination of existing technologies is linked to the competitiveness of the industrial fabric through a plethora of intermediaries. Innovation becomes a complex, cumulative and interactive process because if firms - Small and Medium Enterprises in particular - are to successfully innovate, they must interact with these partners. SME - Small and Medium Enterprises.

mous to allowing innovation and technology transfer projects to crystallise.

A systems perspective on innovation emphasises the desirability of strengthening the current trend away from mission-oriented projects founded in science-push approaches and towards sponsorship of more broadly based programmes that emphasise technology diffusion as much as is possible and reasonable. Of course, the world economic context has evolved drastically in the past years, but mistakes such as the Hermes mini-shuttle cannot and should not be repeated.

For the space sector it looks relevant to increasingly adopt the governing rules of innovation policy while remaining close to those of research policy. Both policies must be conducted in close interaction and on an equal footing.

By following the guidelines of innovation policy the space sector could be made stronger and increasingly popular. Only then, will some of the grandest projects like the exploration of the Solar System or the development of new propulsion techniques become more acceptable. But before that, the need is to demonstrate on the widest possible scale the high return on investment offered by space projects.

Technology Transfer: A Practical Framework

The actual technology transfer phase is only one part of the innovation process. It is an important one of

course and ESA, for example, has already been successful here (Figures 4 and 5) through the creation of Spacelink Europe, a Groupement d'Intérêt Economique of technology-broker companies.

The creation of networks is a useful initiative which tends to improve the diffusion aspect of innovation: it is not much good transferring technology or know-how from the space sector to another sector if that transfer is limited to one supplier and one user only!

Networking will permit participants to broaden their insight in a number of areas: technology transfer skills, technological expertise and know-how, services portfolio, organisation and management, etc.

At NASA, in the sixties, the systems approach to innovation translated to the more or less direct participation of a large part of the scientific community in the space effort. This allowed a substantial feed-back from space technology development programmes through the involvement of scientists of different backgrounds specialising in different technological sectors. Accordingly, there were also early attempts at increasing US university involvement in the technology transfer process. Thus, the traditional discovery role of the university became effectively coupled to the technological needs of industry.

Links between higher education institutions and industry are part of a global innovation strategy. This holds in the space sector where efforts should be made for developing more

technologies of the generic type (i.e. common to a number of industrial sectors) through the interlinkage of space institutions, universities and other public laboratories, the space industry and other types of industries. According to the most recent innovation surveys, networking, informal contacts and mobility of skilled employees appear to be the most important forms of technology transfer in many countries.

A Case for Europe

In Europe, innovation policy in general and networking infrastructure in particular must be supported by regional, national and European authorities. A space policy should be developed in the light of a close ESA-European Union relationship and in the context of industrial competitiveness. The space sector would then find at least part of the rationale and the synergies it now requires.

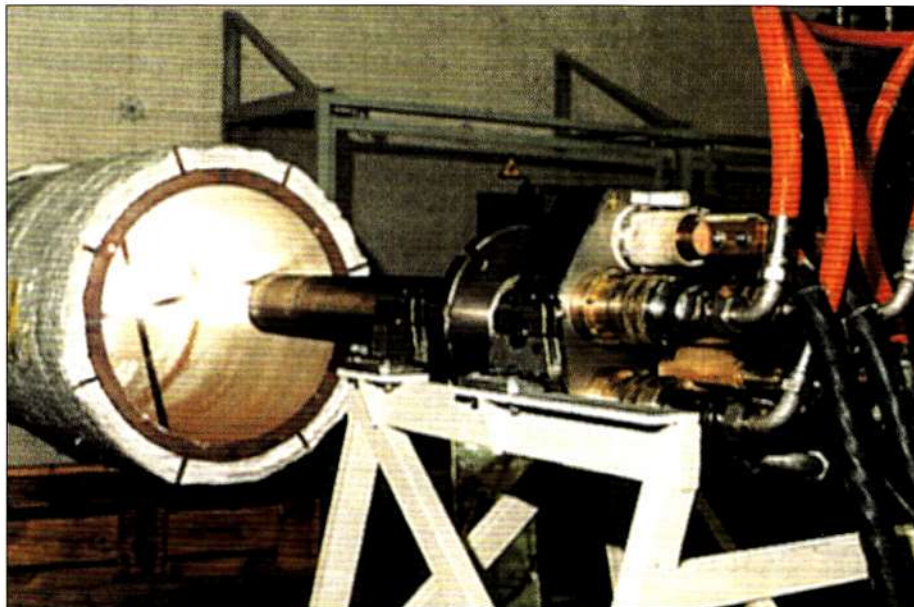
Synergetic actions are already taking place between ESA and the Community in a number of areas including Earth observation, education and training, telecommunications and environmental issues. However, concrete action frequently remains to be implemented.

There is now both an opportunity and a need for the Community to contribute more towards Europe's space effort, and give consideration to:

- The political, economic and industrial dimensions of the challenges and issues which need to be addressed collectively;
- The sectorial mission and competence of ESA, which is mainly an agency for the research and development of space technologies and systems; and
- The need to integrate space activities

Figure 4: Plasma generators have been developed by the French company Aérospatiale both as potential propulsion systems and for the simulation of atmospheric re-entry conditions. The technology was adapted to superheating the air for blast furnaces and cupola furnaces, as the system can heat gases to temperatures in excess of 10,000 °C.

Ceramics, metals or thermoplastics can be fed into the device and sprayed out as a plasma for material deposition/coatings of uniformly high quality. Much larger surface areas can be covered in one sweep, making "paintbrush" applications possible. It can also be used as an advanced plasma welding device.



into the broader socio-economic fabric of Europe (especially Earth observation and satellite communications which are space-derived activities driven by objectives outside the space sector).

The military market should also expand in Europe in order to allow it to have its own spy satellites and corresponding infrastructure so that full autonomy (particularly from the US) may be acquired. This is an important issue not only regarding future European defence policy, but also considering the technological spin-offs that could be generated and the actual size of the space market in Europe.

In 1991, the European space industry had a turnover of around 2.6 billion ECUs (1 ECU = 78 pence) and employed about 25,000 people. The same year, the US space industry had a turnover of 26 billion ECUs and employed more than 260,000. This large difference is due to the size of the government markets in the US which are 14 times greater than in Europe. It happens that over 50% of this market is for the military when the corresponding figure is no more than 10% in Europe. Of course, such markets are not open to international competition and so the US space industry therefore benefits from a large captive market.

This is not to say that military applications for space should be developed extensively. However, the making of a single market clearly allows some sleeping markets to grow, thereby increasing overall spending and spin-offs to and from the space sector.

Conclusion

At the level of large firms in the space sector, it would be useful to



Figure 5: Software developed by ACS of Italy can handle large quantities of digital data from on-board sensors and provide a real-time imaging capability. The software also provides geometrical correction and referencing to the satellite data in order to obtain precision reference maps. It is now applied in a number of different fields back on Earth, including in particular blood flow monitoring. The software can be made to produce real-time images of human blood flow, making it a useful diagnostic tool for circulatory diseases.

define a strategy for the transfer of each specific technology. Also, successful transfer programmes should be copied (another form of technology transfer!) and proactive thinking adopted at all levels of design and engineering. Potential spin-offs must be investigated in the early phases of projects and in close co-operation between the various partners.

National and regional authorities are aware that an adequate environment is a pre-condition for the successful transfer and diffusion of technologies. Future space policies should adopt some of the characteristics of innovation policy to allow the technology transfer process to become increasingly common. This could be a way of bringing the space sector closer to Small and Medium Enterprises and the general public. It would help to improve prospects for higher space budgets.

The image making of the space sector is closely linked to technology transfer. Marketing and promoting space technology is a fundamental activity which all those who are involved in the space sector should endeavour to improve.

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Optical Inter-Orbit Communications

ESA and Japan Sign Up for Inter-Orbit Link

On 7 December 1994, a Memorandum of Understanding was signed by Mr J-M. Luton, Director General of ESA and Mr M. Yamano, President of the National Space Development Agency (NASDA) of Japan for an inter-orbit link experiment at optical and S-Band frequencies between the ARTEMIS satellite of ESA and the OICETS (Optical Inter-orbit Communications Engineering Test Satellite) of NASDA.

Under this agreement which constitutes the first major collaboration between ESA and NASDA in the field of satellite telecommunications, the ESA ARTEMIS satellite, which will be placed in geostationary orbit, will relay experimental data links to and from the low Earth orbiting OICETS satellite.

Purpose of Optical Inter-Orbit Communications

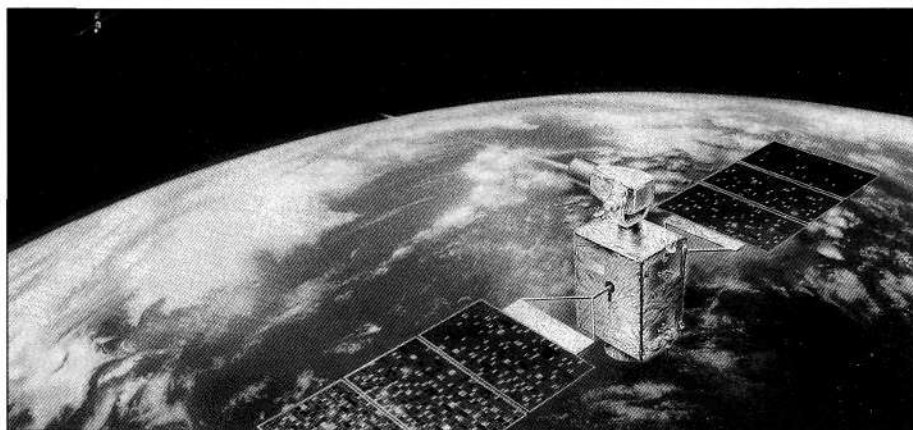
Intersatellite communication is growing more important as a communications infrastructure in space. NASA has already put into operation the tracking and data relay satellite system (TDRSS) using the Ku-band and the S-band. TDRSS was used to relay in real time to the ground the pictures of the first Material Processing Test of 1992 and the Second International Microgravity Laboratory of 1994 which were both conducted aboard space shuttles.

In the near future, an increasing number of Earth observation satellites is expected to be launched and full-fledged operation of the space station would be anticipated to increase the volume of information to be transmitted via intersatellite communications. Furthermore, the time will come when intersatellite communications by radio frequency alone will not be able to meet these ever-growing demands for information. In order to deal with the coming situation, due attention has been paid to optical communications which have a much larger capacity for transmitting information than radio. Therefore, various research activities on optical inter-orbit communications are underway in many space agencies around the world.

Current Research

Optical fibre communications are the dominant form of ground communications, spreading high-speed networks with Gbps ability all over the world. In contrast, optical inter-orbit communications is currently in the first stage of on-orbit experimentation and has numerous problems to solve before it can be applied practically.

NASDA's office of Research and Development has started to evaluate laser sources for communications which require high power and high-speed modula-



OICETS in orbit.

NASDA

tion. This study is a new experiment combining an optical amplifier for producing high power and high-speed coherent communications which is beyond the concept of ground optical fibre communications. In addition, another in-house study has started on evaluation technology of the far field pattern and of design/analysis algorithms.

Future Optical Intersatellite Communications and Its Problems

The coming 21st century has been called the Optical Age. In this context, there are high expectations for optical intersatellite communications as the nucleus of a space communications infrastructure. In the future, image data like HDTV pictures will be sent directly from space to the ground, and optical communications with the Moon or Mars will be possible.

There are many technological and research problems to be cleared up before highly reliable optical intersatellite systems will be feasible. These problems include not only the evaluation of laser sources for transmission, but also developing

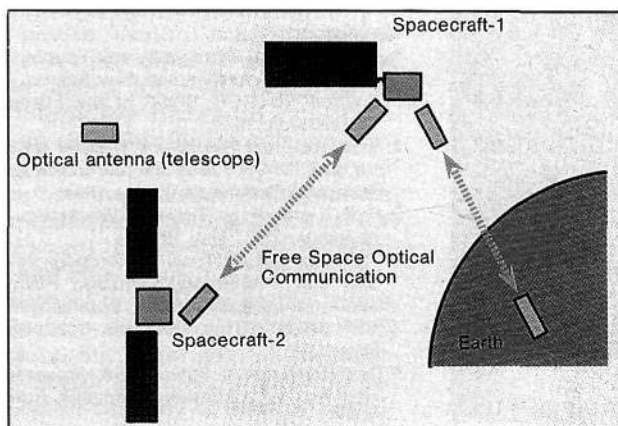
highly sensitive receivers; ensuring small, light-weight and accurate acquisition and tracking systems and compensating for Doppler shift. These problems require space experiments for verification.

The ARTEMIS satellite currently scheduled to be launched in 1997 is part of ESA's plan to set up an orbital data relay service to allow satellites to communicate more quickly and with high data rates to the ground. The use of optical frequencies for such links represents a major technical advance. Optical frequencies have the potential for very high capacity and for secure communications using small terminals. In addition to an optical capability, ARTEMIS will provide data relay links at Ka-Band (23 to 27 GHz) and S-Band (2 GHz). The ARTEMIS satellite will also carry an advanced L-Band payload providing communications to mobile users, such as cars and lorries, throughout Europe, including Western Russia.

The OICETS satellite currently scheduled to be launched in October 1998 by the NASDA J-1 launch vehicle will be placed into an orbit at an altitude of 500 km. Its primary objectives are to conduct

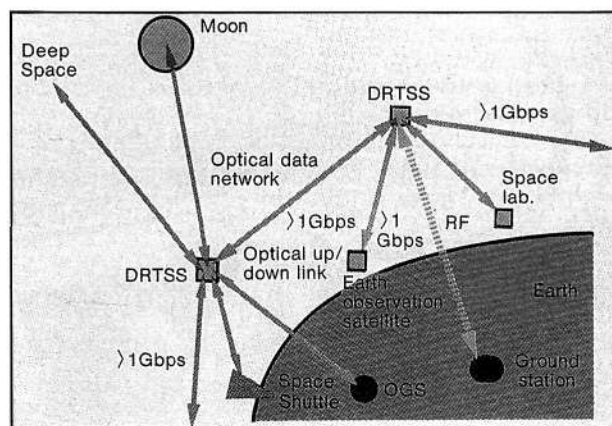
Concept of optical inter-orbit communications.

NASDA



Optical inter-orbit communications as a space infrastructure.

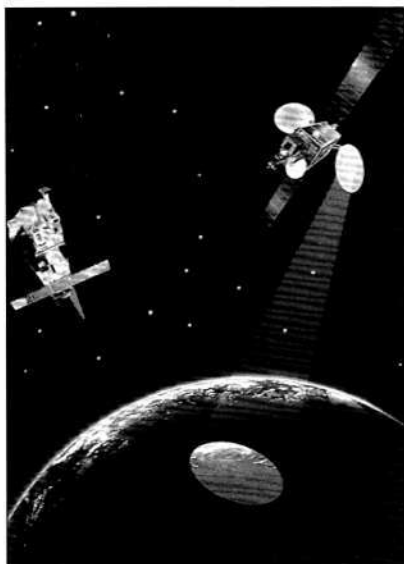
NASDA



orbital demonstrations of pointing, acquisition and tracking technology as well as other technologies for optical communications. OICETS will have a mass in orbit of approximately 500 kg and will use S-Band links for its telemetry and telecommands. Its optical communications equipment is located in its upper section and has an internal 1-gigabit data recorder and micro-vibration monitor.

The laser beam divergence from OICETS to ARTEMIS is about 0.0003 degree, so very accurate beam pointing technology is required for OICETS to communicate with ARTEMIS, especially since they are in relative motion. In this context, OICETS must maintain a laser beam pointing accuracy of ± 0.0001 degree.

Currently, the final stage of a model design of OICETS has been reached in preparation for ground tests. ■



ARTEMIS (Artist's impression). ESA

(Based in part on NASDA Reports No. 28, October 1994 and No. 32, February 1995 and on information from ESA.)

'Space Movies' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

P.G. Stanley	London
P. Stewart	Glasgow

The correct answers are: 1. C; 2. A; 3. B.

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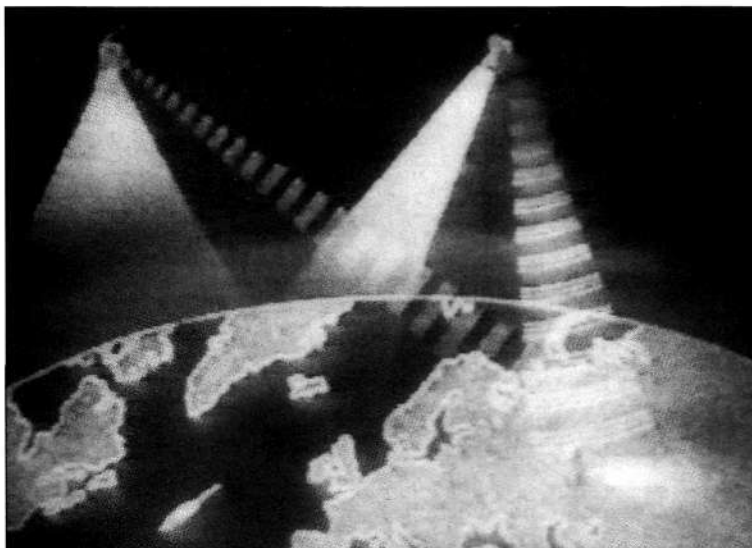
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CLASSIFIED ADS may be placed by Society members at the rate of 53p per word inc. VAT (non-members £1.06 per word inc. VAT). All classified advertisements must be pre-paid. Cheques and postal orders should be payable to the British Interplanetary Society.

Correction

In the reference to General Henry Cooper on p.80, col. 3 of the March 1995 issue, the title given to Henry Cooper was incorrect as he was a civilian scientist and not a military officer.

Lifting the Veil of Secrecy: Exclusive Report



Two Oke series early warning satellites in animated video demonstrating the detection of a submarine launched ballistic missile and relaying warning data to a ground terminal in Russia.

Soviet Military Space Programmes in the 1980s

The end of the Cold War has led to a gradual lifting of the veil of secrecy which covered the military space programmes of both superpowers. The United States finally declassified the existence of the National Reconnaissance Office in September 1992. But rather surprisingly, more details have emerged in recent years on the various military space programmes of the former Soviet Union than on classified space programmes of the US. This article discusses several of the Soviet programmes and includes for the first time pictures of a number of formerly classified Soviet military space satellites.

"Oke" Early Warning Satellites

From February 1960 to October 1966, the United States conducted a number of launches of the Midas early warning system under the name "Program 266." Contrary to popular misconception, however, there were no early warning system satellites launched by the United States between the launch of the last Program 266 satellite on October 5, 1966 and late 1970. Beginning in November 1970 the United States began operating a new system known as the Defense Support Program, consisting of three geostationary satellites equipped with infrared detectors and used to detect the hot exhaust plumes of Soviet ICBMs.

Unlike the United States, however, the Soviet Union did not enjoy the benefits of friendly allies around the globe in which to base ground stations and was also too far north to take full advantage of geostationary orbit. Beginning in 1972 it started launching early warning satellites into highly inclined, highly elliptical orbits commonly referred to as "Molniya" orbits after the class of communications satellites commonly deployed in them. These

unusual orbits are used so that the satellites which are observing the United States are high over northern latitudes and thus still within line of sight of Russian ground stations while viewing the continental US. By comparison, the US uses ground stations in Europe and Australia and has been trying to develop a crosslink system for data.

This early warning system was known as "Oke" and did not become fully operational until 1976. At that time, the Soviets began fielding a nine-satellite constellation. This

would ensure that two satellites were approaching or retreating from apogee at any given time, allowing the satellites to view both the missile fields in the continental US and presumably the North Atlantic.

The disadvantage of such a system is that it does not allow coverage of the Pacific Ocean against attacks from American submarine launched ballistic missiles. To close this gap, the Soviets began operating a second system beginning in October 1975 with the launch of Cosmos 775, which took up an operational station at 335° East. The first four satellites to assume this

BY DWAYNE A. DAY

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Washington DC

role, Cosmos 775, 1546, 1629, and 1894, were all of the original Oke design. After that and beginning in 1988 with the launch of Cosmos 1940, these geostationary satellites were replaced by a new design known as "Prognoz" and similar to the Spektr series of satellites.

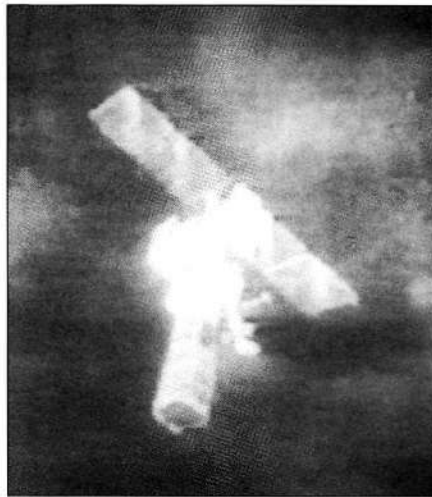
The configuration of the Oke satellites was a state secret until recently. In 1993, a Russian documentary shown on Moscow television and called, appropriately, "Secret Space," revealed the Oke design for the first time. Two photographs from the television programme and of poor quality are reproduced here. One is taken from an animated short of the satellite in orbit, pointing Earthward. It clearly shows the satellite's infrared telescope sunscreen as well as the straight solar panels. The second photograph shows a ground test deployment of the square collapsible sunscreen. The sunscreen is extended with the assistance of four double-strut extenders and is shown partially deployed. Deployment is very quick—under two seconds—and the sunscreen is apparently made of some kind of synthetic fabric.

The satellite in the photographs differs somewhat from line drawings published in the West based upon Russian sources and it is not clear if the differences are due to changes in the satellite design over time, or to errors in the original accounts.

Soviet RORSAT Satellites

Another interesting Soviet military space programme, which has now been discontinued, was the Radar Ocean Reconnaissance Satellite, or RORSAT. RORSAT was a nuclear-powered satellite which was an adjunct to the conventionally-powered Electronic Ocean Reconnaissance Satellite, or EORSAT.

The RORSATs operated in an orbit of approximately 255 km. They had a lifetime of approximately 2-3 months and the Soviets never had year-round coverage with the RORSATs like they did with the EORSATs. RORSAT launches often coincided with large US Navy and NATO naval exercises. The RORSAT satellite carried a fairly powerful phased-array X-band radar which it pointed at the surface of the ocean to search for naval vessels, particularly the broad, flat, highly reflective surface of an aircraft carrier's flight deck. The problem with operating a radar from orbit is that it needs to be close enough to the Earth in order to detect the reflected radar energy (which is considerably weaker than the original radar beam) but it also needs to be far enough from the Earth in order to be able to cover a large surface area. RORSAT was a tradeoff between these two competing interests. Because the Soviets could not build a powerful enough radar to operate from a higher orbit, the RORSAT had to operate in a lower



An animated video of a Soviet Oke series early warning satellite in Earth orbit.



A ground test of an Oke series satellite sunscreen deployment.

orbit than the EORSATs.

But this presented other problems. If the radar was to be powered by solar cells, the solar panels would have to be quite large and would generate a great deal of atmospheric drag at the lower altitude. This would in turn require large amounts of manoeuvring fuel to reboost the orbit of the satellite. As a result of this problem, the Soviets chose instead to power the radar with a compact, multi-cell thermionic nuclear reactor with an output of approximately two kilowatts. The problem with this arrangement is that the reactor is in such a low orbit that it will eventually fall to Earth in a relatively short amount of time (less than a year) at the end of its service life. The Soviets addressed this problem by attaching a secondary rocket to the reactor which would boost it to a higher orbit (approximately 930 km) at the end of its service life. In this higher orbit, the reactor would pose no danger of reentry before its radioactive fuel had decayed naturally.

Between December 1967 and March 1988, the Soviets launched 33 RORSAT reactors into space. Cosmos 198 and 209, launched in December 1967 and May 1968 respectively, have now been positively confirmed as carrying RORSAT reactors. There were also two apparent launch failures of RORSATs and it is not clear if the early reactor launches included radar systems. However, this programme met with a number of highly visible failures.

The most notable of these failures was Cosmos 954, which reentered and landed in Canada in January 1978. Cosmos 954 was a major public relations disaster for the Soviet Union and resulted in the United Nations, deliberations concerning the use of nuclear power sources in space as well as legal claims against the Soviet government. Following the accident, the system was redesigned to expel the reactor core from the reactor at the end of the mission to facilitate disintegration in the high atmosphere in the event of accidental reentry. In 1983, Cosmos 1402 reentered over the South Atlantic and its reactor core was apparently ejected.

Further design changes were made during the 1980s that included systems designed to automatically boost the reactor into the higher orbit following the failure of attitude control, reactor pressurization or electrical systems. It was apparently the failure of the satellite attitude control system on Cosmos 1900 that caused the last minute boost of the reactor in 1988, shortly before it was to reenter after commanded reboost attempts proved futile.

Apparently, this final brush with calamity caused the Soviets to abandon the programme altogether. Only one more RORSAT was launched in 1988 (Cosmos 1932, which was launched before Cosmos 1900 malfunctioned) before the programme was discontinued. It is not known if any further RORSAT reactors or satellites still exist, although the Russians have reportedly privately offered to sell the reactor to the United States.

The "Secret Space" documentary mentioned previously also revealed for the first time the Soviet RORSAT satellite. A grainy image reproduced on the opposite page shows one of the satellites sitting on a wheeled trailer inside a building with two technicians sitting at a table alongside. In the image, the satellite's phased array radar antenna is being deployed. The antenna, which is supported by a cable from an overhead crane, is semi-circular and runs along one side of the satellite body. It folds out and back on a hinge, to then extend directly behind the satellite. It is not fully deployed in the still photograph. Below the extendable antenna is most likely the mounting point for the ion thrusters which the satellite was believed to use.

Barely visible in the videotape is another panel running along the satellite body which may be another antenna, thus giving the satellite a total antenna face twice its length. The reactor, apparently not attached during this test, would be mounted at the opposite end of the satellite along with the electrical power and control bus and the reactor boost disposal stage. At the end of its lifetime, the extended antenna was jettisoned and the reactor and its reboost stage separated from the

main cylinder to push the reactor into a 930 km disposal orbit.

New Details on the Extensive Soviet Space Nuclear Power Programme

On 1 February 1987, Cosmos 1818 was launched into an 800 km orbit. On 10 July 1987, Cosmos 1867 was launched into a similar orbit. Both satellites contained an advanced multi-cell thermionic nuclear reactor known as "Topaz." Cosmos 1818 operated for six months and Cosmos 1867 operated for approximately one year.

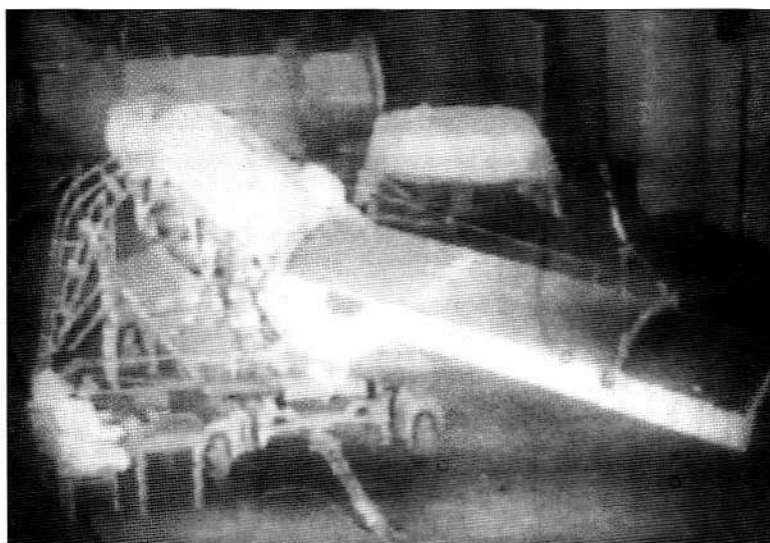
Earlier reports have put the reactor's output at 10 kW, but it is now known that it was more in the range of 5-6 kW. The Topaz reactor was a multi-cell design built by the Krasnaya Zvezda ("Red Star") design bureau. Multi-cell reactors have fuel elements which are stacked atop each other like batteries in a long flashlight. Krasnaya Zvezda was the same design bureau responsible for the RORSAT reactor. The increased power of the reactor corresponds well with the higher orbit, making it likely that the Topaz reactor was developed for a follow-on-RORSAT intended to operate in the higher orbit and therefore prevent any more embarrassing accidents like Cosmos 954.

While Topaz was being tested, another Soviet design bureau, the Kurchatov Institute, was developing another space nuclear reactor with an output of 6 kW, nearly the same as Topaz. This was a single-cell reactor known as "Enisy." The Enisy reactor was being developed for a classified geosynchronous application, possibly for a large strategic communications or early warning/battle management satellite.

Unlike the RORSAT and Topaz multi-cell reactors, the single-cell design uses a single uranium crystal fuel element in each of its cells. The great advantage of this design is that it allows the reactor to be fully tested on the ground without the use of radioactive fuel. Tungsten heaters are inserted into the spaces where the fuel elements would normally be mounted and they can then generate enough heat for the reactor systems and efficiency to be tested.

A total of 28 Enisy units were built from 1970 to 1988. There were three classes of reactors. "V" system reactors were fabricated only for thermophysical or mechanical systems tests. "Ya" system reactors were not flight rated, but could undergo thermophysical, mechanical, cold temperature and nuclear (zero power and nuclear ground tests). "Eh" system reactors were fully flight qualified and could be used for all four system tests. The Ya-24 reactor was full power nuclear ground tested for 14,000 hours starting in December 1978. Ya-81 was tested for 12,500 hours starting in September 1990.

When the Kurchatov Institute first



A Soviet RORSAT satellite during ground test of radar antenna deployment.

announced the existence of its Enisy reactor in 1989, Western analysts thought that this was the Topaz reactor flight tested in 1987. They thus mislabelled it "Topaz." When they learned that this was actually a previously unknown Soviet reactor, they relabelled it "Topaz II" and renamed the original Topaz as "Topaz I." Soon after, the Kurchatov Institute unexpectedly offered to sell its Enisy reactor and the US Strategic Defense Initiative Organization (SDIO) expressed an interest in purchasing it. Kurchatov was short of money to pay its employees and the Soviet military had cancelled the Enisy programme in 1988. Kurchatov was thus very interested in obtaining hard currency to continue operating, even if this meant selling a formerly top secret piece of equipment to the American military.

Procurement of the first two reactors, V-71 and Ya-21u, along with support equipment and Russian technical services, was authorized in March 1992 and negotiations were finalized in April. The total cost of acquisition was \$13 million. The reactors were delivered to a special test facility in Albuquerque, New Mexico, and were evaluated under the Thermionic System Evaluation Test (TSET). Both reactors were non-nuclear tested six times and have now reached the end of their service lives. In March 1994, the Ballistic Missile Defense Organization acquired the remaining four Enisy reactors from Kurchatov. These reactors are all flight-qualified and known as Eh-40, 41, 43 and 44.

A plan to fly at least one of the reactors under the Nuclear Electric Propulsion Space Test programme was cancelled in summer of 1993 due to lack of funding. The Ballistic Missile Defense Organization now concentrates on defence against tactical ballistic missiles and therefore lacks a requirement for space-based systems. The Department of Energy also opposed the Topaz II procurement in part because it had been the final nail in the coffin of DoE's own troubled

programme, the SP-100. Furthermore, the Clinton administration has adopted an anti-nuclear stance. Topaz II was thus in danger of being cancelled, despite the fact that the United States has never developed this technology and now owns all of the equipment. Fortunately, this programme represented an area of high-technology co-operation between the United States and Russia, and also fulfilled a desire to deter Soviet nuclear engineers from seeking employment elsewhere. The TSET programme has now been turned over to the Defense Nuclear Agency, which has responsibility for conducting nuclear weapons tests. Testing of the Eh-40 and 41 reactors will begin in 1995. If any decision is made in the future to fly one of the reactors in space, it will likely only be the Eh-44 reactor, with the Eh-43 remaining as a ground test and engineering model.

Surprisingly, the Soviets also had a third nuclear reactor programme under extensive development during the 1980s. This reactor, developed by the NPO Energiya design bureau, was a 150 kW thermionic reactor which was lithium-cooled. It was apparently intended to be scaled-up to the megawatt range. Several ground tests were conducted, although no complete systems test was apparently ever conducted and the system was still many years from reaching a flight qualified stage. Officially, the Russians will only state that the reactor was being developed for a human Mars exploration mission. However, it appears much more likely that this reactor was under development for the extensive Soviet SDI programme. The US also was evaluating multi-megawatt reactors to power laser and particle-beam weapons for strategic defence.

Acknowledgments

The author would like to acknowledge the assistance of Mike Evans, formerly Topaz programme Manager for the Ballistic Missile Defense Organization, and Joe Wetch of Space Power Incorporated for their assistance.

The Secret Story of the Soviet Space Shuttle

H. Matthews, Walter Roberts, 131 Alameda Avenue, Fircrest, WA 98466-6204, USA, 1994, 100pp, send \$19.95 to the above address.

This slim paperback is devoted wholly to the story of the ill-fated Soviet Shuttle, Buran. It begins with an historical account of earlier Russian interest in spaceplanes and follows with a description of the development work for Buran, proper. The book concludes with an account of Buran's one and only flight and includes details of crew selection and training.

The Superpower Space Race: An Explosive Rivalry Through the Solar System

R. Reeves, Plenum Publishing, 233 Spring Street, New York, NY 10013-1578, USA, 1994, 437pp, \$28.95, ISBN 0-306-44768-1.

The launch of Sputnik 1 by the former USSR on 4 October 1957 was viewed by the West as a threatening show of power, leading to space rivalry between the USSR and the US whereby each became determined to prove its technological superiority to the world.

During the intense competition which followed, both countries made amazing advances in space which resulted in thrilling close-ups of other worlds in our Solar System.

The Space Age was, therefore, something of a rare in-

Astronautics Selection

stance in history. It was a time when both nations mobilised their best and brightest talent to work with single-minded dedication towards a specified goal. Supported by enormous funds and employing top scientists and engineers, the space programmes on both sides of the Iron Curtain provided the determination and genius needed to achieve what had formerly been deemed impossible.

Both Soviets and Americans landed craft, with amazing precision, on the surface of the Moon: American probes touched down on the Surface of Mars while the Soviets built those able to withstand the enormous heat and pressures of the surface of Venus.

This story of conquering the inner Solar System is one of brilliant achievement, occasionally marred by tragedy, whereby each hard-earned mission became both a political triumph for the nation involved as well as a scientific triumph for man as a whole.

The book chronicles the his-

tory of the American and Soviet unmanned exploration of the inner Solar System during the period from the late 1950s to the 1970s. Throughout this time space exploration was not only a triumph of science and technology but also a cold war battleground as both nations fought for technological supremacy. The American side was generally open to the public gaze but details of the Soviet side have only recently been brought into the open, hence the topicality of this book.

The Future of US Rocketry

E. Hujsak, Mina-Helwig Co., PO Box 1292, La Jolla, CA 92038-1292, USA, 1994, 201pp, \$29.95, ISBN 1-886133-01-8.

This new publication by a Fellow of the Society is most timely as the rocket industry, which made space programmes possible, has reached a plateau which now invites examination of its future direction.

When the US undertook to develop rockets as part of its mili-

tary capacity, there was little anticipation then of the broad-based space industry which subsequently evolved. In the event, the lapse was of only a few years before the first space launchings were attempted.

Space exploration was made possible by the development of modern rockets, kindled by the work of the early pioneers and fanned by the enormous advances, leading to the V2 made by the Germans during WW2. Since then, thousands of space flights have been made, worldwide, utilising a wide range of rocket designs. In recent years, however, the position has changed considerably and hence we have this book, which is designed to enable a broad readership to assess how US launch systems will survive in a time of budget constraints, lowered demand and intense overseas competition.

We Have Lift-Off: History and Photos of Shuttle Launches

E. Case, Gazelle Book Services Ltd., Falcon House, Queen Square, Lancaster, LA1 1RN, 183pp, £13.50, ISBN 0963303309.

This book contains data and photographs of Space Shuttle launches from Mission STS-1 to STS-56 (including Mission 51-L, the Challenger accident). It gives not only the dates, times and details of each launch but also provides a summary of each mission.

All the photographs were taken by the author.

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

'Microgravity Facilities' Competition

Microgravity research could yield numerous possible technology transfers from the space sector particularly when the International Space Station becomes operational. (See above: 'Technology Transfer and the Space Sector' by Daniel Routier). Many microgravity facilities have already been developed and put into operation and some of these feature in this month's competition.

Prizes: The first three correct entries to be opened after the closing date of 4 May 1995 will receive a copy of the book:

International Cooperation in Space The Example of the European Space Agency

(The story of ESA by R.M. Bonnet and V. Manno and published by Harvard University Press, Fitzroy House, 11 Chenies Street, London WC1E 7ET, 1995, ISBN 0674458354, 163pp, £29.95. Details of contents appear in the March issue on p.85.)

To Enter: Identify the microgravity facility referred to in each of the following four cases by the name obtained by substituting a consonant for an asterisk. (All four facilities have previously been mentioned in *Spaceflight*.)

1. For hands-on experiments in physics/life science: **O*E*O*
2. For study of cells and complex biological systems: *iO*a**
3. For study of human physiology in space: A****O*a**
4. For study of materials transitioning from the liquid to the gaseous state: **i*i*a* *o*i** *a*i*i**.

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England
To arrive by first delivery on 4 May 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name

Address

.....
.....

IAF Congress 9-14 October 1994

Israel Invests in Space Technology

- A Low-Cost Launch Vehicle for Light Spacecraft
- A Light Platform for Observations of Earth and of Sky
- A Geosynchronous Lightsat for Commercial Communications

The total Israeli budget for space research and development is around \$50 million a year.

From this budget, the Israel Space Agency (ISA) receives \$4 to 5 million to support university space activities and, especially, the development of the TAUVEK - an original X-ray telescope - to be carried on the Russian Spectrum X-ray astrophysics satellite (to be launched by Proton in early 1996).

The AMOS project, which is a lightsat for communications and broadcasts, is a commercial venture without any direct funding from the government.

Israel Aircraft Industries (IAI) is the driving force of Israel's space programme through its subsidiaries as follows.

MLM System Engineering and Integration

This organisation is marketing 'Next', an improved version of the Israeli Shavit-I launch vehicle. It is a three-stage solid rocket: the first two

MBT Systems & Space Technology has space environment simulators to test satellite systems. This facility is located in the industrial area of the Ben Gurion International Airport.



Israeli satellites are controlled from this centre at MBT Systems & Space Technology in the industrial area of the Ben Gurion International Airport. TP/SIC

BY THEO PIRARD

Belgium

stages, produced by TAAS-Israel Industries Ltd, Rocket Systems Division, are identical (functioning for one minute with a specific impulse of 240 s), while the third spherical stage is made by Rafael.

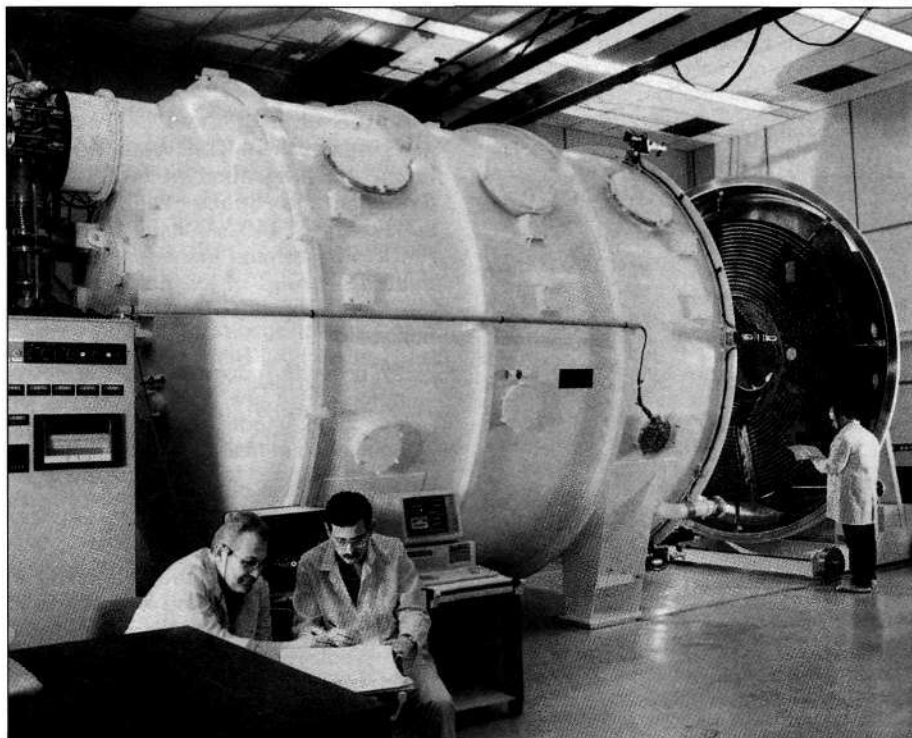
'Next', as marketed in the USA by Space Vector Corporation, has a fourth stage with a storable bipropellant engine which is used to achieve low Earth orbit with great accuracy. The navigation system employs one low-cost strapdown platform, an Inertial Navigation Unit and a GPS receiver. The gimbaled platform of the inertial navigation unit is located in the second stage and is used for initial alignment and for accurate navigation during the two first stages. The GPS unit is installed in the fourth stage and takes over the inertial navigation system after the second and third stages.

MBT Systems and Space Technology

This organisation is developing a light platform, with precise three-axis stabilisation, to carry small payloads for astronomy and astrophysics or for Earth observations with high-resolution cameras. This bus is to be tested with Ofeq-3, a 230 kg technological spacecraft which would be equipped with a high-resolution camera. The launch of Ofeq-3 is not yet firmly decided and the launch vehicle may even be a non-Israeli launch vehicle, because a satellite designed for Earth observations has to fly in a sun-synchronous polar orbit and it is not possible to reach polar orbits from the Palmachim base.



Israel is marketing its technology in solid propulsion. This spherical solid engine is used on the third stage of the Shavit launch vehicle. TP/SIC



IAI is the prime contractor of the AMOS programme for a first Israeli light satellite in geosynchronous orbit for communications and broadcasts. Through two subsidiaries - SpaceCom Satellite Communication Ltd in Israel and Magyarsat Corporation in Hungary - it plans to operate and market the commercial services offered by the AMOS spacecraft. Hungary is to be the first customer of AMOS technology. In late 1995, AMOS-1 will beam signals to that country.

Details about Ofeq-3, AMOS and Israel's microsatellite Techsat 1 appear overleaf. ■

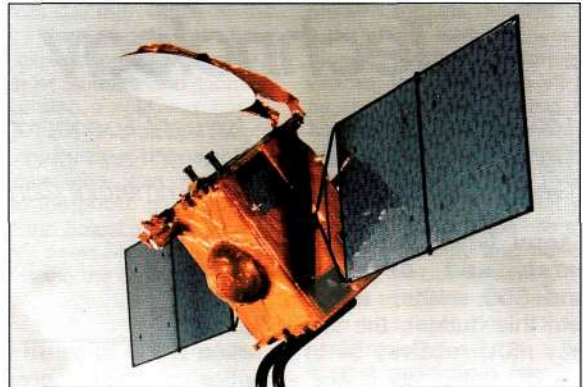
Small Is Beautiful

Mini and Microsats Find International Favour

Theo Pirard presents an overview of current developments with small satellites arising from the use of micro-miniaturised components. Small satellites offer a much reduced cost of operations in orbit or in the Solar System and are allowing developing countries and small laboratories to extend their space programmes. This information is based mainly on reports given at the 45th IAF Congress held in Jerusalem, Israel. For reports from the Congress on launch system developments see *Spaceflight*, December 1994, p.398 and on Earth Observation see *Spaceflight*, January 1995, p.20.

BY THEO PIRARD

Belgium



Israel's AMOS-1 communications satellite.

IAI/MBT

Israel

Israel is mainly developing lightsat technology for space science and applications. Three significant projects are coming to completion with satellites to be launched in 1995:

- Techsat 1/Gurwin 1 is a 50 kg three-axis microsatellite, with three-axis stabilisation and Earth-pointing capability, developed at the Asher Space Research Institute, Technion (Israel Institute of Technology). This ambitious project aims at joining academy and industry in a coherent activity and at educating students in space technology. It is being achieved with large donations from the Asher family of Chicago and from J. Gurwin of New York, and with the technical assistance of ISA (Israel Space Agency), IAI-MLM (solar arrays) and El-Op (opto-electronics).

The first microsatellite of Israel has a gyrostatt attitude control based on a momentum wheel, a static horizon sensor, three magneto torquers and a three-axis magnetometer. It is designed to provide a digital store-and-forward

system for amateur radio purposes. It also carries a UV whisk-broom scanning spectrometer for Earth albedo measurements, X-ray detectors for astronomical observations and a CCD camera with image processing and control card. Techsat 1 will be launched piggy-back on a Zenit rocket into sun-synchronous orbit at 680 km.

- Ofeq 3 is the first of the second-generation light satellites of Israel. A 250 kg platform with three-axis stabilisation is being proposed and marketed by IAI-MLM to carry payloads for astronomy or for remote sensing purposes. For the next mission of this Israeli minisatellite bus, there is a high-resolution light-weight electro-optical scanner or Earth Resources Monitoring System developed by El-Op. Ofeq 3 was designed for launch with the Israeli Shavit booster, but could be launched by a Russian rocket. Recently, IAI would have made an agreement with an American company, Core Software Technology of Pasadena, to use Ofeq 3 as a commercial remote sensing satel-

lite to produce 2 m resolution images.

- AMOS-1 is a light-weight and low-cost geosynchronous satellite for communications and broadcasts and the first satellite of this type with a mass of some 500 kg in orbit and an intended life of ten years.

In 1990, the AMOS project became a fully owned venture of IAI (Israel Aircraft Industries), a governmental corporation which received from the government of Israel a guarantee for the lease of up to three transponders on the first satellite. This commitment between IAI and the government was finalised in January 1992. For the development of the satellite, IAI needed the technological support of well-established manufacturers of space systems. Contracts were signed with Deutsche Aerospace Dornier and MBB. French Alcatel Espace are contributing to the programme as major subcontractors. ANT Bosch Telecom in Germany and Space Systems Loral in USA are major suppliers of components.

At the time of the Congress, the flight model of AMOS-1 was in its last phase of integration at Israel's MBT Systems and Space Technology (a subsidiary of IAI). Amitsur Rosenfeld, AMOS Programme Manager, who conducted a group of journalists through the test, integration and control facilities, said:

"In order to reduce the cost of development, we are working directly on one flight model. Our work will be completed in March, when the satellite will be shipped to Interspace and to Alcatel Espace in Toulouse for environmental tests and final integration."

AMOS-1 is due to be launched in September by an Ariane 44L and is to be positioned in geosynchronous orbit at 4° West. Its payload offers nine Ku-band transponders, seven of which would be available to follow two spot beams, one centred on Israel to cover

The engineering model of the Ofeq-3 platform on the exhibition stand of Israel Aircraft Industries (IAI).

Th.P./SIC



the Middle-East (with a 750,000 km² footprint where 250 million inhabitants are living!) and the second on Hungary to cover Eastern Europe.

Argentina

SAC-B or Satellite de Aplicaciones Cientificas-B will be the first scientific satellite of Argentina. Developed jointly by CONAE (Comision Nacional de Actividades Espaciales) and NASA, this 190-kg spacecraft will be launched in April 1995 by a Pegasus rocket and placed in a 550 km circular orbit with an inclination of 37°.

The Argentine scientific satellite will be inertially stabilised and permanently oriented to the Sun. It will observe hard X-rays from solar flares and will survey the sky with X-ray CCD sensors along an axis perpendicular to the Sun line. The survey instrument will be pointed at 3° x 3° fields of view for a day or two and then rotated about the Sun line to new parts of the sky. As the Earth revolves around the Sun, the survey instrument will gain access to the entire sky. The size of the satellite is 0.76 m x 0.89 m and it has a design life of three years.

Germany

In Germany, three microsatellite developments are underway:

OHB-System has launched the first 50 kg SAFIR (Satellite for Information Relay) payload for a two-way global communication, tracking and monitoring system as an attached payload on the Russian Resurs satellite launched on 4 November 1994. The complete SAFIR satellite constellation will consist of six satellites at an altitude from 700 to 1,000 km in inclined orbits. OHB is looking at an intersatellite-links concept as a further development. (*Spaceflight*, January 1995, p.5).

Kayser-Threde is developing for Telespazio the Temisat system of data collection and relay with microsatellites. It is also preparing and proposing to microgravity users the MIRKA or Micro Re-entry Capsule, attached to a Russian Foton spacecraft. MIRKA is a spherical capsule with a diameter of 1m and a total mass of about 150 kg. By using Foton's infrastructure until after the de-orbit manoeuvre no MIRKA-specific attitude control system, retro-engine or even battery power for in-orbit thermal control is required. MIRKA, for its first mission in mid-1996, will be equipped with three different German experiments for heatshield, rarefied flow and pyrometry studies.

The Technical University of Berlin, Institute of Aerospace has developed and operated two microsatellites, named Tubsat, equipped with a CCD camera and three-axis stabilisation system and used for experiments in data and voice communications. For the third microsatellite, Tubsat-C, currently in preparation, it is cooperating with Deutsche Aerospace Bremen,

RKK Energiya and Rockwell International to develop an Inspector vehicle for the Mir complex in orbit. This small unmanned service vehicle - to be used later for the International Space Station - will be tested in a demonstration flight during 1996. Inspector, exhibited on the stand of the German Teldix company, will have a mass of 72 kg and dimensions suitable for launch in a Progress spacecraft. Covered by solar panels, this free-flying microsatellite will be highly manoeuvrable and will be equipped with a high-quality colour video camera.

JPL/NASA

The Jet Propulsion Laboratory has developed, through the Mars Pathfinder programme, a low-cost approach of the exploration of Mars. The Mars Pathfinder is being prepared in a quick mode for launch in December 1996 with a Delta II rocket. It will land on Mars in July 1997. Its technological payload is to pave the way for future landers on Mars. It comprises a miniature rover with on-board autonomous navigation.

Japan

Japan appears to be the advocate of miniaturised space systems for lunar and interplanetary exploration. The Institute of Space and Astronautical Science is developing the Lunar-A probe consisting of an Orbiter and three Penetrator Modules. This probe, planned for launch in 1997, represents a total mass of 520 kg to be injected into lunar transfer orbit. Each Lunar Penetrator consists of an ogive shaped nose, a solid de-orbit motor and rhumb-line attitude manoeuvring system. The National Space Development Agency of Japan (NASDA) is considering unmanned lunar exploration with a Lunar Polar Orbiter and a small Moon rover.

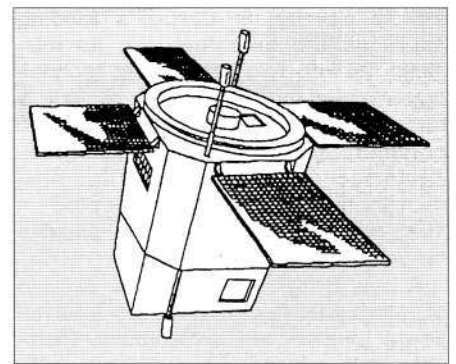
Russia

The Russian Space Research Institute (IKI) and the Lavochkin Association of Babakin Engineering Research Center are also looking for lightsat technology to be developed for 120-150 kg mass interplanetary probes. They presented a study of a 120 kg Pluto fly-by probe equipped with a descent capsule. A launch opportunity with an improved Proton vehicle was considered for February 1999 with arrival close to Pluto in June 2007, after 7 to 8 years of interplanetary flight.

Italy

Italian Alenia Spazio is working on the design and development of the light M-BUS platform for scientific spacecraft of 200-300 kg. Missions being considered are:

CESAR (Central European Satellite for Advanced Research) which is a joint venture promoted by Central European countries: Italy, Austria, Po-



Argentina's 190 kg scientific satellite (SAC-B) with dimensions 0.76 m x 0.89 m.

land, Czechia, Slovakia and Hungary for a scientific satellite of 297 kg to investigate the Magnetosphere-Ionosphere-Thermosphere (MIT) system. This spin-stabilised spacecraft will be placed in an eccentric orbit between 400 and 1,000 km.

JUNO is an Italo-American 295 kg satellite in UV astronomy in the framework of the NASA SMEX programme and will combine a payload funded by NASA and a platform, supposedly funded by ASI (Italian Space Agency).

COSMO (Constellation for Mediterranean Observation) is a trinational project of remote sensing satellites, studied by Italy (with Alenia Spazio), Spain (with INTA) and Greece (with Intracom). Alenia Spazio, acting as prime contractor, is looking to introduce a mini-satellite constellation system equipped with optical and microwave sensors.

France

The French Space Agency CNES is considering a next generation of scientific satellites using a fast production line of minisatellites. Each spacecraft has to cost \$35 million (including \$15 million for the bus) and is to be developed within 18-24 months. First launch would take place in April 1999.

Ukraine

The Ukrainian Yuzhnoye Design Office is proposing a unified series of low-cost minisatellites for the world community of lightsat users. These spacecraft, named MS, with mass from 70 to 180 kg, use gradient-gravity stabilisation and gas-jet propulsion systems.

Czech Republic

The Czech Academy of Sciences is developing small subsatellites for the Interball programme to study the magnetosphere. During 1995, two Magion-type satellites will be released from Prognoz-type spacecraft: C2-T (Magion-4) and C2A (Magion-5), each with a mass of 58.7 kg and will have manoeuvring capability in an eccentric orbit and study plasma flows and energetic particles.

United Kingdom

Surrey Satellite Technology Limited which is wholly-owned by the Univer-

sity of Surrey, is Europe's leading microsatellite manufacturer. Its missions fall into two categories: technology-transfer missions which include a large educational component, and commercial missions with no significant technology-transfer. Its next microsatellite launch is expected in 1995 with the military CERISE satellite for Alcatel Espace (France).

A new British entrant in the domain of microsatellites is Satellites International Limited (SIL), Newbury, Berkshire (UK). It provides the MicroSIL bus for the second microsatellite, Badr-B, developed by SUPARCO in Pakistan. This light spacecraft will carry an Earth imaging and VHF/UHF store-and-forward payload.

China

China is investigating the possibility of launching several 250 kg spacecraft by a single Long March 4 vehicle for use in the framework of its Small Satellite Remote Sensing (SSRS) system to increase the revisiting frequency of the same place more than once or twice a day with visible and infrared sensors and a resolution of 100 m.

Brazil

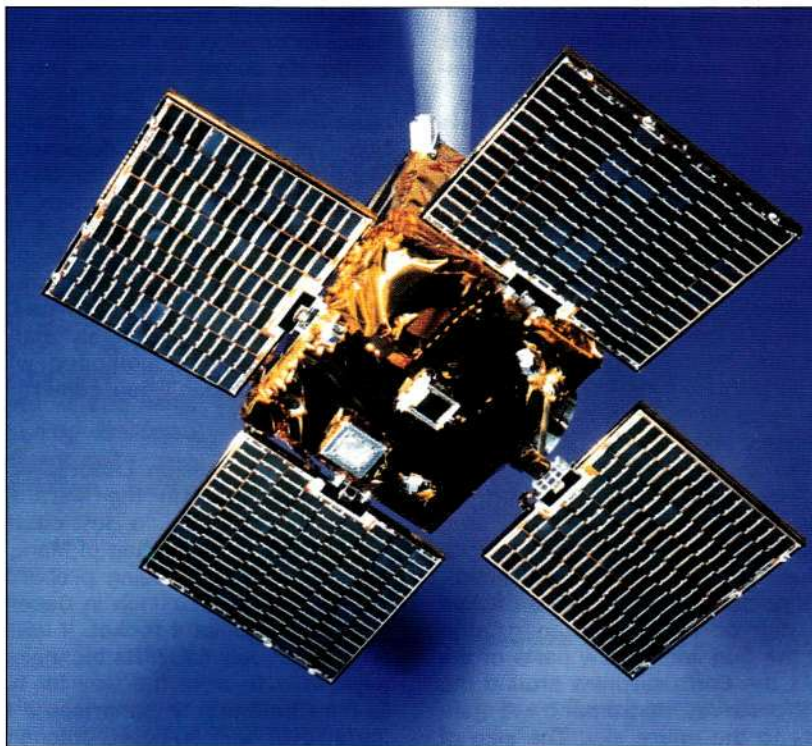
Brazil is developing small indigenous satellites for data collection (SCD) and for Earth observations (SSR) which it hopes to launch with the VLS rocket. It is proposing constellations of eight small satellites for equatorial communications (the ECO-8 system) and for worldwide observations (the WOM-8 system).

Belgium

Belgium is studying and promoting, through the ESA Telecommunications Programme, a Little-LEO Messaging System (LLMS) called IRIS (Intercontinental Retrieval of Information via Satellite). This LEO store-and-forward messaging and localization service is planned to start operations within a two-year timeframe, with two payloads in sun-synchronous orbit, using the SAFIR concepts developed by the German OHB-System company of Bremen. The pilot project calls for an overall budget of some 25 million ECUs (\$30 million), including flight models, ground infrastructure and a first network of 1,000 portable terminals. The space segment could be the result of a Belgo-German cooperation: SALT System of Brussels, prime contractor acting as system designer, payload developer and system operator; Alcatel Bell Telephone of Anvers, major subcontractor for the communications payload and for the integration of the spacecraft; OHB-System of Bremen, responsible for the spacecraft and for their launches from Russia.

Ireland

Ireland, with the technical assist-



The Astrid spacecraft at the Swedish Space Corporation, Solna, in December 1994 - all tested and ready for transport to the Plesetsk launch site in Russia. The solar panels are deployed and the body is covered by thermal insulation blankets. To be seen also are, in the far corner a sun sensor, on the edge of the forward deck a rectangular S-band patch antenna, centrally on the same deck a test sample of a new type of solar cell, and placed in a triangle the three hooks of the separation system. Looking out from the side is the main instrument, a neutral particle imager.

SWEDISH SPACE CORPORATION

ance of Surrey Satellite Technology, is preparing EISAT-1, a 50 kg microsatellite to be launched in sun-synchronous orbit at 550 km. Its payload will consist of scientific instruments for particle radiation monitoring, for ionospheric measurements and for Earth observations (with a lightweight CCD camera). The EISAT project is the work of Space Technology Ireland, St Patrick's College, Kildare; but it needs international participation for financial support.

Finland

Finland, through the Helsinki University of Technology, is working on its first microsatellite, named HUTSAT, to be launched in 1997 by an Ariane 4 vehicle into polar orbit for geophysical research. The 50 kg HUTSAT, especially designed for an Ariane 4 launch, uses an original modular structure covered by solar arrays and stabilised by a 6 m long boom which will provide a magnetically clean platform for the vector magnetometer.

Mexico

Mexico is developing two microsatellites. PUIDE (University Research & Development Space Program) will launch an engineering spacecraft within the next few months. IMC (Instituto Mexicano de Comunicaciones) plans to launch in 1995 SATEX-1, a 50 kg test satellite with a CCD camera, a Ka-band receiver, a data collection system and a GPS receiver.

Sweden

The Swedish Space Corporation, with an increasing annual budget for space science and technology (\$92 million for 1993-94) is developing small spacecraft and payloads mainly for studies in magnetospheric, ionospheric and atmospheric physics. Three satellites are in preparation as successors of Viking (launched by Ariane 1 in February 1986, operated until May 1987) and Freja (launched by Long March 2 in October 1992, still active):

- Astrid 1, the first Swedish microsatellite, was launched on 24 January by a Russian Cosmos rocket. Its total mass is about 20 kg and its payload consists of instruments to measure natural particles and electrons in the magnetosphere and of UV photometers to image the aurorae.
- Astrid 2 - still in the phase of preliminary study - will be launched one year later to study electric and magnetic phenomena around the Earth.
- Odin is a Swedish minisatellite of 200 kg to be launched from Russia in 1997 for an operational lifetime of two years. It will carry a payload for spectroscopic studies at submillimetre and millimetre wavelengths of astronomical objects and processes in the Earth's atmosphere. Odin, designed to serve both astronomy and aeronomy, is being carried out as an international programme with Canada, France and Finland. ■

Biological Contamination of Mars

Unless space-faring nations are careful to keep the general public aware of the issues of biological contamination, a well meaning but poorly informed public could halt an expensive and possibly quite harmless space mission. Environmental groups have already shown their willingness to bring lawsuits against major space organisations to halt space missions. Thus, the critical life sciences issue of biological contamination must be addressed before any Mars landing or sample return mission is launched.

In 1975, the US launched the Viking probes to Mars to search for microbial life. These sophisticated probes carried several experiments to test for the presence of bacteria or microbes and organic compounds. One experiment, the "Labelled Release Experiment", recorded positive evidence, but the other experiments detected nothing. Scientists vary in their opinions about the results of the Viking probes, the general consensus being that the probes failed to detect any form of life.

However, many scientists expect life may exist on Mars, either underground, inside rocks, under a volcano or even on the surface. Much more information about Mars is needed before we can say for certain whether or not life exists there.

On Earth, life has penetrated every niche, including geothermal vents at the bottom of the ocean, inside volcanoes and even inside the cooling systems for nuclear reactors. There are biological species that never see light. There are microbes that live constantly at temperatures above 100 °C. These conditions may exist in some areas on Mars, such as beneath one of the ancient volcanoes, and therefore the possibility of life existing on Mars is not excluded.

Several probes will be launched to Mars over the next decade and there is now debate about whether sending spacecraft to Mars would endanger possible Martian life by accidentally introducing it to terrestrial life forms and also about whether returning a sample of Martian soil to Earth would endanger the Earth by introducing possible Martian life forms into the Earth's biosphere. Just as the native peoples of North America and Australia were unaccustomed to, and hence vulnerable to diseases that Europeans carried in the colonial days, terrestrial microorganisms are likely to be unaccustomed to life that has evolved elsewhere.

Some would argue that there is no life on Mars and so there is no cause for concern and some say that no living organism could survive the journey between Earth and Mars on an unmanned spacecraft. Also some argue that no terrestrial organism could survive on Mars and so there is no need for spacecraft sterilisation. As with all debates, there are opposite

BY ISAAC GRANT BOXX

NSW, Australia

lines of argument. There are those who urge caution in dealing with spacecraft between Earth and Mars. Some argue that life could exist on Mars and that it would be immoral to violate the Martian biosphere by introducing terrestrial life forms to it. Others say that if an organism is hardy enough to survive on Mars, it would flourish in the comparatively fertile conditions on Earth, thus possibly endangering the Earth's biological balance.

Ironically, the Earth may have already been exposed to Martian life forms. This is the result of meteors which originated at Mars and have then come into contact with Earth. It has been theorised that millions of years ago, when life may have existed on Mars, massive asteroid collisions flung pieces of Mars into space. Due to their momentum and the Earth's gravitational attraction some of these pieces found their way to Earth. Some even survived the fiery entry through the atmosphere and landed at least partially intact on the surface. Although carrying no evidence of life several such meteorites have been located around the world, the most famous being those found at Shergotty, Nakhla and Chassigny. Life in the Solar System may indeed have originated on Mars and, as a result of asteroid collision, found its way to Earth where it evolved into what we know as life today.

NASA, ESA and any other space agencies planning a Mars mission should raise public awareness of issues and risks involved with such missions, small though they may be. A public education campaign about the risks and rewards of Mars missions would help not only to ensure that no public concern arises from Mars exploration missions, but would also help space agencies to gain public support for space exploration.

An armada of Mars probes is currently planned. The MESUR Pathfinder, the Mars Global Surveyor programme, the Mars-96 probe and a Japanese Mars orbiter are to be launched to Mars by the end of the decade with several more planned for early in the next century. It is estimated that there

About the Author



Isaac G. Boxx

Isaac Boxx is an 18 years old, homeschooled student. He describes himself as having always been interested in space science, and intends to pursue a career in this field. He is beginning university studies this year for a dual degree in aerospace engineering and theoretical physics. Isaac lives with his family near Mudgee, NSW, Australia.

will be up to twenty-five Mars probes launched by the year 2010. Unless there is some meaningful progress on the issues of contamination of Earth and Mars, it is possible that these may be halted, thereby halting scientific exploration of the planet.

The problem of biological contamination of Solar System bodies is currently being addressed by several organisations. The most influential of these groups is COSPAR, the Committee on Space Research, a member of the International Council of Scientific Unions. Possible back contamination as a result of a sample return missions brings in departments of agriculture, environmental groups and health organisations.

Independent space activist organisations such as the British Interplanetary Society and the Planetary Society have an important role to play in the decision making process. This is an area of space exploration that we will be hearing much more about in the near future. I hope members of the British Interplanetary Society will give this important issue serious thought and contribute to the debate on it. ■

One-page 'INTO SPACE' articles offer readers the opportunity to express their ideas and 'think aloud' on topics which they see as important and of interest to others. Contributions of an appropriate (one-page) length may be sent to the editor at any time and should be accompanied with a photo of the writer (head and shoulders) and a few lines of personal details.

Apollo-13 Lunar

On 13 April 1970, the Apollo-13 spacecraft carrying three American astronauts was on its way to the Moon when it was crippled by an explosion. The emergency return to Earth had the world holding its breath for the next four days and was one of the most public and dramatic rescues of all times.

On the next four pages we look back at what NASA described as a "successful failure", due to the rescue experience gained.

BY ED HENGVELD
The Netherlands

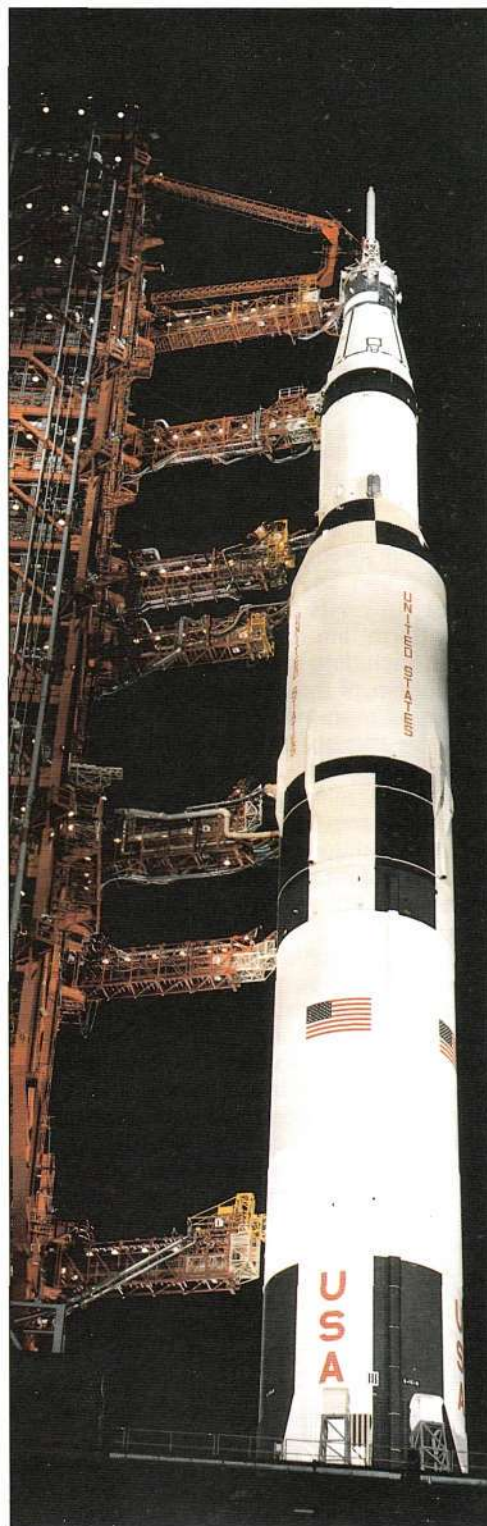


The Apollo-13 crew was announced on 6 August 1969 and consisted of (left to right) commander Jim Lovell, command module pilot Ken Mattingly and lunar module pilot Fred Haise. They were to attempt the third manned lunar landing.

NASA

Lovell and Haise were to spend three days exploring the Fra Mauro region of the Moon. The two are seen here practising their tasks during a simulation at the Space Center in Houston.

NASA



This night shot of the Saturn-5 launch vehicle was taken on 24 March 1970, during the countdown demonstration test. It was on this day that things started to go wrong, as de-tanking procedures damaged the insulation inside oxygen tank No. 2 in the silver-coloured service module at the top of the rocket. NASA

Mission Drama

The Mission

(all times Houston time)

Saturday 11 April

1:13 pm

Apollo-13 is launched from KSC; centre engine of the Saturn-5's second stage shuts down 132 sec early, but the other four engines compensate by burning 34 sec longer. Third stage and Apollo spacecraft enter parking orbit around the Earth.

3:48 pm

The third stage of the Saturn-5 is reignited for the 5 min 50.7 sec translunar injection burn towards the Moon.

5:14 pm

During a live TV-transmission, the CSM Odyssey is docked to the LM Aquarius. The spent third stage is sent on a collision course with the Moon.

Sunday 12 April

7:53 pm

The first midcourse correction, a 3.37 sec burn of Odyssey's big SPS-engine, puts the spacecraft on the desired hybrid trajectory needed to reach the Fra Mauro landing site. The spacecraft has now left the so-called free-return

The weekend before the scheduled launch, the prime crew was exposed to rubella, or German measles, while working with backup crewmember Charlie Duke. Examination of the prime crew revealed that Ken Mattingly had no immunity to rubella and thus had to be ruled out for the flight. Use of the entire backup crew, as procedure dictated, was impossible because of Duke's illness and so it was decided to replace Mattingly with his backup Jack Swigert. The disappointed Mattingly would later fly as command module pilot on Apollo-16.

NASA



Launch took place at 13:13 Houston time on Saturday, 11 April 1970 as the giant Saturn-5 thundered upward from KSC's launch complex 39A.

NASA

trajectory, which would bring it back to Earth without any further engine firings.

Monday 13 April

8:24 pm

Beginning of the fourth (and last) TV-transmission from the spacecraft. Lovell and Haise are shown during their first inspection of Aquarius. Lovell closes off saying the crew is getting ready "for a pleasant evening in Odyssey".

9:07 pm

The spacecraft is almost 300,000 km from Earth when oxygen tank No.2 explodes, causing the No. 1 tank to fail also and ripping a large hole in the service module. Oxygen vents into space, causing pressure in the fuel cells to drop to zero. The normal supply of electricity and water is now lost.

9:08 pm

Swigert reports "Hey, we've got a problem here".

10:24 pm

Houston announces: "Here in Mission

Control we are looking toward an alternate mission, swinging around the Moon and using the lunar module's power systems, because of the situation that has developed here this evening".

10:50 pm

The crew abandons Odyssey and enters Aquarius, which will now serve as a lifeboat to bring them back to Earth.

Tuesday 14 April

2:42 am

Aquarius' descent engine is fired for 30.4 sec to put the spacecraft back on the free-return trajectory.

6:15 pm

Spacecraft disappears around far side of the Moon and passes about 200 km above the lunar surface.

6:49 pm

Spacecraft emerges on the other side of the Moon and begins the long journey home.

7:10 pm

Third stage of the Saturn-5 crashes on

EXPLOSION IN SPACE

the Moon.

8:40 pm

Aquarius' engine is fired for a 4 min 23.4 sec burn to speed up the return to Earth.

Wednesday 15 April

3:38 am

On instructions from the ground, the crew begins constructing adapters to use Odyssey's supply of lithium hydroxide cartridges to purify cabin air in Aquarius. Without this, they would be killed by their own exhaled carbon dioxide.

7:38 am

Spacecraft enters the Earth's gravitational sphere of influence.

2:23 pm

Battery No. 2 in Aquarius' descent stage explodes, causing a momentary drop in power. However, the other three batteries compensate by increasing their electrical output.

10:31 pm

Aquarius' engine is fired for 15.4 sec to correct the trajectory.

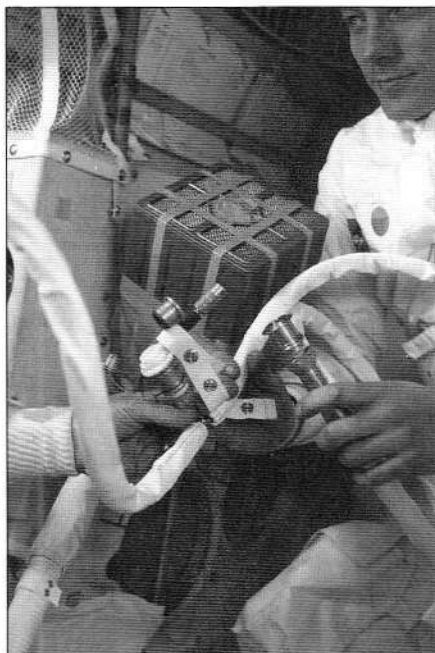
Thursday 16 April

1:59 am

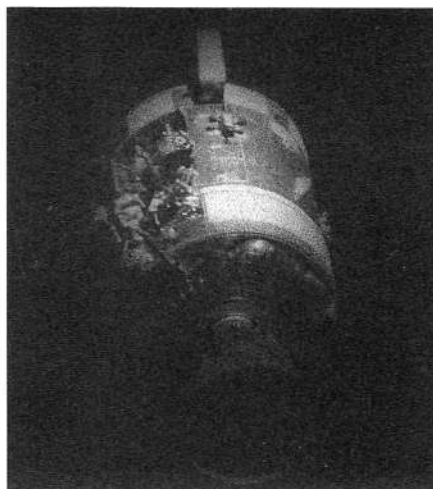
Aquarius' helium burst disk ruptures, as it is designed to do, because heat from repeated firings of the descent engine has caused an increased rate of pressure build-up in the supercold helium tank used to pressurise the fuel tanks.

Jack Swigert connects a hose that will carry urine into a disposal bag. Normally the astronauts dumped urine overboard, but it was feared this might throw the ship off course. Floating beside Swigert is an improvised lithium hydroxide filter from the command module to help cleanse carbon dioxide from the air.

NASA



On the day before Apollo-13 splashed down in the Pacific Ocean, flight director Glynn Lunney confers in Mission Control with his team. NASA



After the service module was jettisoned the crew caught only a quick glimpse of the damage caused by the explosion. NASA

NASA

Friday 17 April

6:52 am

Aquarius' attitude jets are fired for 22.4 sec to correct the trajectory.

7:14 am

The service module is jettisoned, enabling the astronauts to photograph the damage from the explosion before it burns up in the atmosphere.

10:43 am

Aquarius is jettisoned and also burns up.

11:53 am

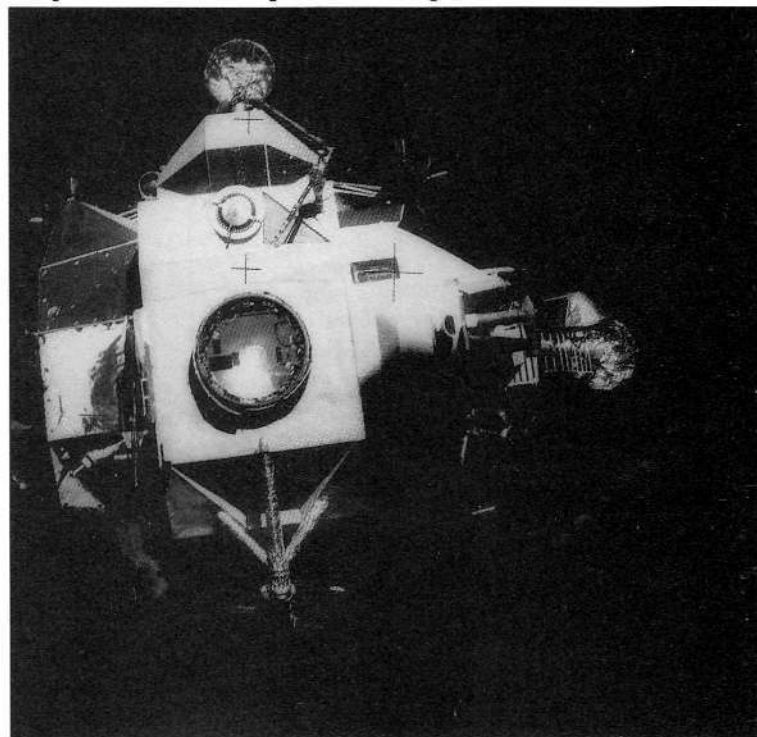
Reentry of the command module begins.

12:07 pm

The command module splashes down in the Pacific Ocean, 142 hrs 54 min 41 sec after launch.

NASA

"Farewell Aquarius, and we thank you" was the comment as Aquarius was jettisoned to burn up in the atmosphere.





The day after their return to Earth the astronauts were presented with the Presidential Medal of Freedom by President Richard Nixon in Hawaii. NASA

What Caused It All?

The Apollo-13 Review Board, chaired by Langley Research Center director Edgar M. Cortright, presented its findings on 15 June 1970. The board concluded that the explosion in oxygen tank No. 2 was caused by "an unusual combination of mistakes, coupled with a somewhat deficient and unforgiving design". Ed Hengeveld provides the details.

The service module of the Apollo spacecraft contained two spherical oxygen tanks, manufactured by Beech Aircraft Corp., for the prime Apollo contractor, North American Aviation. Each tank contained 145 kg of oxygen, two thirds of which was for fuel cell electrical production and the remaining third for cabin breathing air. Part of the tank assembly consisted of a heater, a fan and temperature and pressure sensors, all of which were immersed in the supercold liquid oxygen and all of which were powered by spacecraft electricity.

The 1962 specification called for use of 28 volts of power, which was used in the Apollo spacecraft. In 1965 however, North American issued a revised specification for the tank and heater assembly, stating that the heaters should be able to accommodate 65 volts because this was used at KSC during ground tests. Beech complied, but somehow neglected to change the specification for the tank's thermostat switches.

After passing acceptance tests, oxygen tank

No. 10024X-TA0009 left the Beech plant on 3 May 1967 and was shipped to North American. On 4 June 1968, it was installed in service module 106, slated to fly on Apollo-10. Design changes in the spacecraft necessitated removal for modifications. During removal operations on 21 October 1968, the shelf assembly containing the tank was dropped 5 cm, which caused a poorly fitting fill tube to jar loose. This was not noticed at the time and after modifications the tank was

The Command Module of Apollo-13 is now exhibited in the Museum of Aviation and Space at Le Bourget airport, Paris, France. TOMAS PRIBYL



installed in service module 109 for the Apollo-13 mission on 22 November 1968.

On 15 December 1969, the Saturn-5 launch vehicle carrying the Apollo-13 spacecraft was rolled out to launch pad 39A at KSC. On 24 March 1970, launch crews filled the command module's liquid oxygen tanks as part of the countdown demonstration test, the final dress rehearsal before launch. When the test was over, tank No.2 refused to be emptied because of the damaged fill tube. To remove the liquid oxygen from the tank, it was decided to switch on the heaters so the contents would boil off. The thermostat switches, which were designed to open when the temperature in the tank exceeded 27°C, immediately fused shut when they were subjected

to 65 volts of power instead of the 28 volts they were designed for. The fan and heater ran continuously for 8 hrs in order to force the oxygen from the tank. Without a working thermostat, the temperature rose to 538°C, high enough to seriously damage the Teflon insulation around the wires.

The tank was finally emptied, but when it was later filled again for launch it was a potential bomb waiting to go off. It did just that at 55 hrs and 54 min after launch when a spark from the bare wires caused its contents to explode. ■

Apollo 13: 'What Might Have Been'

BY BEN EVANS
West Midlands, UK

On 13 April 1970, one of the most harrowing episodes in the history of manned Spaceflight unfolded as the Moon-bound Apollo 13 spacecraft suffered a crippling explosion in one of two oxygen tanks located inside its service module (SM). Four days later, miraculously, the three-member crew - mission commander James Lovell, lunar module pilot Fred Haise and command module pilot Jack Swigert - returned safely to Earth having drawn on the power and propulsion supplies of their lunar module (LM) as the first space lifeboat.

As the 25th anniversary of 'Unlucky Thirteen' approaches, this article looks at its objectives had it succeeded. It was to have been the United States' third manned lunar landing mission with two extravehicular activity (EVA) sorties planned to carry out scientific exploration of the bleak Fra Mauro foothills on the edge of the Moon's Ocean of Storms.

Journey to Lunar Orbit

The Apollo 13 mission began successfully from the Kennedy Space Center at 2.13 pm (EST) on 11 April 1970, after which the spacecraft was scheduled to follow a standard four-day flight profile to lunar orbit. The Saturn V launch vehicle's SIVB third stage was targeted to deliberately hit the lunar surface prior to the landing of the LM, codenamed 'Aquarius', in order that a seismometer implanted on the Ocean of Storms by the Apollo 12 crew five months earlier would record its impact.

A total of 11 colour television transmissions were planned during the Apollo 13 mission. The first occurred some 90 minutes after launch, followed by three on the translunar voyage, one of the Fra Mauro site from an altitude of about nine miles, two from the lunar surface during the EVAs of Lovell and Haise, one at the docking operation between command/service module (CSM) 'Odyssey' and LM Aquarius, one from lunar orbit and two on the return journey.

In general, the flight pattern of the Apollo 13 spacecraft to the Moon would have mirrored those of the earlier Apollo 11 and 12 missions, with the exception that the second of two burns by the CSM engine - used for insertion into lunar orbit - was combined with a descent orbit-insertion burn previously performed by the LM at the start of its 'powered-descent' or 'PD' phase. This 'double burn' would have placed the docked Apollo 13 spacecraft into an orbit of seven x 57 nautical miles, and in doing so would preserve propellant aboard Aquarius for an additional 15 seconds of hover time during the descent phase.

Mission to Fra Mauro

During Apollo's 14th revolution around the Moon, at a ground elapsed time (GET) of 103 hours and 31 minutes, the three-phase PD manoeuvre would have been initiated by Lovell and Haise aboard Aquarius, using the descent engine to brake the vehicle out of its descent orbit and thus commence the 11-minute journey down to

Fra Mauro. The aim of the PD phase was to fire the descent engine in a retrograde attitude when at an altitude of some 260 nautical miles, to diminish the LM's forward velocity to virtually zero by the time a vertical-descent phase was scheduled to begin just 100 feet above the surface.



The Apollo 13 emblem was based on the theme of Apollo, the Sun God, and shows three horses pulling the Sun chariot from the Earth to the Moon. 'Ex Luna, Scientia' means 'From the Moon, Knowledge'. NASA

The first phase of the descent, known as the 'braking' phase, would have seen Aquarius in a 'windows-up' position, enabling data from the LM's landing radar to be integrated continually by the guidance computer and also to maintain better communications through the steerable S-band antenna. The braking phase would have ended at an altitude of some 7,400 feet, at which point Aquarius would manoeuvre to a 'windows-forward' attitude for the 'approach' phase and the astronauts would be given their first glimpse of the landing site. During the final approach and landing phases, the facility for either Lovell or Haise to take over manual control of Aquarius would be available at any point.

Approximately 100 feet above the lunar surface the 'landing' phase was scheduled to begin and by this time all forward momentum in the vehicle would have ended. Descending at a

rate of just three feet per second, Aquarius was scheduled to touchdown just to the north of the large crater Fra Mauro at 9:55 pm EST on 15 April 1970. The planned surface coordinates for the landing were 3.6 degrees south latitude by 17.5 degrees west longitude, at a point some 95.6 nautical miles east of Apollo 12's touchdown site.

Lunar Surface Exploration

Following Aquarius' touchdown, the Moon was to play host to Lovell and Haise for no less than 33 hours and 27 minutes, during which the duo would perform two EVA sessions, each lasting for four hours. A one-hour extension to both excursions was also made available, depending on the physical conditions of the astronauts and on their economical use of consumables.

The first EVA, scheduled to commence only four hours after landing, at 2:13 am EST on 16 April, would have begun with the setting-up of an erectable S-band antenna on the surface to relay voice, television and LM telemetry communications to Earth-based Manned Spaceflight Network stations. After the deployment of the antenna, Haise was expected to climb back into Aquarius and switch from the LM's steerable S-band antenna to the erectable antenna, after which he would rejoin Lovell on the surface to continue work.

The astronauts' initial tasks would have included the setting-up of the now-customary United States flag and also the third Apollo Lunar Surface Experiments Package (ALSEP) station. The latter, consisting of five individual scientific experiments, would have been positioned about 300 feet distant from the LM. The ALSEP-III assembly was stored in a scientific equipment bay located within Aquarius' descent stage, and would have been deployed on to the surface by means of a simple pulley system.

Other objects for the astronauts included gathering up to 95 lb of lunar surface material, including the heat-flow experiment core samples, individual rock specimens and fine-grained fragments from the Fra Mauro site. Extensive photography of the visited areas was also an essential part of their work schedule, including the use of a lunar stereo close-up camera to acquire images of delicate geological formations which would be destroyed if any attempt was made to remove them.

Observations of terrain characteristics, conducting lunar geological surveys, digging a two-feet-deep trench as part of a soil mechanics experiment, and the setting-up of a window-shade-like solar wind composition ex-

periment similar to those erected during Apollo 11 and 12 would complete the 5,000-foot traverse of EVA-1.

The second excursion, scheduled to being at 9:58 pm EST on 16 April, would involve the two astronauts undertaking an 8,700-foot round tour from Aquarius as far as the rim of the ancient Cone Crater. Twelve stops to gather samples were scheduled, including two double core-tube samples from a depth of 27 inches as part of gas-analysis and magnetic experiments.

After the return of Lovell and Haise to Aquarius, the LM would have lifted off from Fra Mauro at 7:22 am EST on 17 April, a seven-minute and eight-second burn of the ascent engine placing them into an orbit of nine x 44 nautical miles. The three-hour rendezvous phase with the CSM would have culminated in a docking and transfer of the lunar crew and their samples to Odyssey and their colleague Swigert at 10:39 am EST. After sealing the connecting hatches between the two spacecraft, Aquarius would have been jettisoned to impact the lunar surface and hopefully return further 'moon-quake' data from the Apollo 12 and 13 ALSEP seismometers.

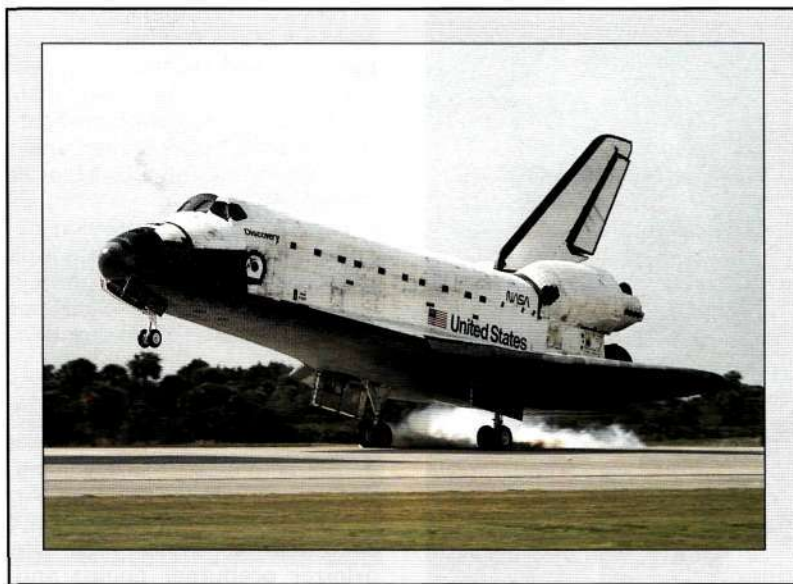
Return to Earth

After the ejection of Aquarius, the CSM was scheduled to perform a plane-change manoeuvre in order that it could be directed over numerous candidate sites for future Apollo landing missions, including Davy Rille, the Descartes highland plains and the crater Censorinus. A large-format lunar topographic camera, carried in Odyssey's crew access hatch, was to have been demonstrated for the first time by taking high-resolution 4.5 inch-square black-and-white images in overlapping sequence for use as mosaics or single frames.

A final firing of the CSM engine at 1:42 pm EST on 17 April was planned to set Apollo 13 and her crew on course for the Earth with splashdown in the mid-Pacific Ocean scheduled to take place at 3:17 pm EST on the 21st. The total mission elapsed time for the Apollo 13 flight, therefore, was expected to be ten days, one hour and four minutes. A standard recovery by the USS Iwo Jima, which provided a Mobile Quarantine Facility (MQF), would carry the three astronauts to Hawaii. From there, a C-141 aircraft was scheduled to transfer the crew back to Houston's Manned Spacecraft Centre and the Lunar Receiving Laboratory (LRL) for a 21-day period of quarantine.

Acknowledgement

I would like to express my thanks to Mr Lee D. Saegesser of the History Office at NASA Headquarters for his assistance in providing archive material used in the preparation of this article. ■



STS-60 glides effortlessly on to Runway 15 of KSC's Shuttle Landing Facility for a flawless landing on a sunny Florida day. NASA

Eighty-One Days in Space

A Review of 1994 Space Shuttle Flights

BY KEITH T. WILSON

Lanarkshire, Scotland

During 1994 the US Space Shuttle flew seven missions carrying 41 humans into low Earth orbit for a total duration of 81 days 10 hours and 22 minutes.

All four of NASA's Shuttle orbiters were used to fly the wide variety of scientific missions which began with STS-60 in February and ended with STS-66 in November. Brief highlights are given for each 1994 flight in chronological order and mission statistics can be found in the Table on p.134.

STS-60: Discovery

The mission was launched on-time at 7:10 am EST on 3 February and marked the first flight of a Russian cosmonaut on the Space Shuttle as part of an agreement between NASA and the Russian Space Agency (RSA) on cooperation in human space flight. The flight was the 60th Shuttle mission and marked the return of the commercial Spacehab module to orbit. Spacehab carried twelve experiments, four involving materials science; seven involving life sciences and also a space dust collection experiment. Also on board was the Wake Shield Facility, making the first of a series of flights.

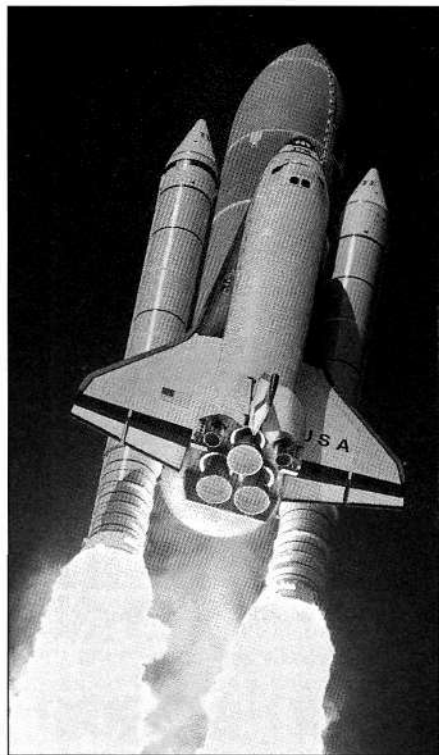
The first attempt to deploy the Wake Shield Facility was made on flight day three. The free-flying experiment platform was designed to leave a vacuum wake in orbit in which high quality thin film layers of gallium arsenide and other semiconductor materials could be grown. However the first attempt was called off due to radio interference and difficulty in reading status signs on the platform. A second attempt was also called off due to problems with the platform's attitude control system. The Wake Shield Facility remained suspended from the

orbiter's remote manipulator system where five out of a planned seven films were grown. The platform will fly again on STS-69 in July 1995.

A number of NASA/RSA joint in-flight medical investigations were carried out and Russian cosmonaut Sergei Krikalev made use of the Shuttle Amateur Radio Experiment (SAREX) to talk to amateur radio operators in his native country. Conversations between the crew and US President Clinton in Houston and Russian Prime Minister Chernomyrdin in Moscow were also carried out.

STS-60 carried the 100th Get Away Special canister to fly in space and the crew were involved in several deployments from GAS cannisters. Six Orbital Debris Radar Calibration Spheres ranging in size from 5 to 15 cm were deployed to aid calibration of world-wide radar tracking systems. The German, University of Bremen's BREMSAT was also deployed from a GAS cannister to measure conditions such as acceleration forces affecting satellites.

Discovery's first attempt at a KSC's landing on 11 February was called off due to unfavourable weather but a successful landing was achieved later in the day at 2:19 pm EST.



STS-62 is launched at 8:53 am (EST) on 4 March 1994. NASA

STS-62: Columbia

Unfavourable weather resulted in a one-day launch delay with liftoff taking place at 8:53 am EST on 4 March.

Primary payloads located in Columbia's payload bay were the US Microgravity Payload-2 (USML-2) which included five experiments investigating materials processing and crystal growth in microgravity and the Office of Aeronautics and Space Technology-2 (OAST-2) which included six experiments focusing on space technology and space flight. A variety of middeck experiments were also flown including Advanced Protein Crystal Growth;

Commercial Protein Crystal Growth; Middeck Zero Gravity Dynamics Experiment and Bioreactor Demonstration Systems. The crew also conducted a number of biomedical activities aimed at better understanding and countering the effects of prolonged spaceflight.

The fourteen day mission came to an end on 18 March when Columbia glided down on to KSC runway 33 at 8:09 am EST to end a highly successful two weeks of microgravity research.

STS-59: Endeavour

STS-59 suffered from two launch delays before successfully lifting off at 7:05 am EST on 9 April. On 7 April the launch was postponed to allow for inspections of SSME high pressure oxidizer preburner pumps and an 8 April launch was halted due to unfavourable weather.

The primary payload aboard Endeavour was the Space Radar Laboratory-1 (SRL-1) which included the Spaceborne Imaging Radar-C, the X-Band Synthetic Aperture Radar and an atmospheric instrument called Measurement of Air Pollution from Satellites (MAPS).

Endeavour's space radar covered over 38 million miles of the planet (20%) and included the imaging of more than 400 sites including 19 primary observation sites in Brazil, Michigan, North Carolina and Central Europe. Over 133 hours of data were collected. The MAPS experiment measured the world-wide distribution of carbon monoxide in the lower atmosphere.

Various Get Away Special experiments were flown from a number of countries including France and Japan.

STS-59 also marked the first flight of

Toughened Uni-Piece Fibrous Insulation (TUFI), an improved thermal protection tile. Several of these tiles were placed on Endeavour's base heat shield between the three main engines.

The mission ended on 20 April at 12:54 pm EDT when the orbiter touched down at Edwards Air Force Base in California following three call offs at KSC due to unfavourable weather.

STS-65: Columbia

With a mission duration of over two weeks, the flight of STS-65 became the longest Shuttle flight to date. Launch occurred on time on 8 July at 12:43 pm EDT following a smooth countdown. Aboard Columbia on its second flight was the International Microgravity Laboratory (IML) carrying more than twice the number of experiments and facilities flown on its first mission. The crew members, which included payload specialist Chiaki Mukai, the first Japanese woman to fly in space, were divided into two teams to perform 24 hour research.

Over eighty experiments from six space agencies were located in the Spacelab module in the orbiter's payload bay. Fifty of these involved life science research including bioprocessing, space biology, human physiology and radiation biology. The Japanese space agency provided the Aquatic Animal experiment Unit which consisted of two independent systems that supported studies of live fish and small amphibians. These contained Medaka fish, goldfish, and newts. Some of the equipment had flown on previous Spacelab flights such as ESA's Biorack which was making its third flight.

Nearly thirty experiments in materials processing were carried out using nine different types of facility. The solidification of materials from a liquid state in a containerless environment was provided by the TEMPUS facility while crystals were grown in another facility called The Advanced Protein Crystallization Facility.

The crew took time off during the mission to commemorate the 25th anniversary of the Apollo 11 moon landing mission noting that it also featured a spacecraft called Columbia. Aboard STS-65 was an Apollo 11 plaque which had hung at KSC's Launch Control Center since 1969. The plaque was returned following the landing of the Shuttle.

The mission was extended one day due to showers in the landing area with touchdown occurring at 6:38 am EDT on 23 July at KSC runway 33.

STS-64: Discovery

STS-64 was launched on 9 September at 6:22 pm EDT after nearly a two hour delay due to unfavourable weather. The mission marked the first flight of the Lidar in Space Technology

STS-59 provided this radar image of a part of Isla Isabela in the Western Galapagos Islands, which lie about 1200 km west of Ecuador in the eastern Pacific and have six active volcanoes. Since the time of Charles Darwin's visit to the area in 1835, there have been over 60 recorded eruptions on these volcanoes. NASA





STS-65 landed at KSC on 23 July 1994 and astronauts Robert D. Cabana (right) and Donald A. Thomas give the 'thumbs up' sign having broken the Shuttle flight duration record with a mission duration time of 14 days 17 hours and 56 mins.

NASA



The STS-64 mission tested the new Simplified Aid for EVA Rescue (SAFER) system some 130 nautical miles above the Earth. Astronaut Mark C. Lee is here operating the jet backpack as he floats free of Discovery.

NASA

Experiment (LITE) and also the first untethered US spacewalk since 1984.

The LITE experiment, which uses laser pulses instead of radio waves to study the Earth's atmosphere, operated for 53 hours, yielding more than 43 hours of high-rate data. The experiment obtained views of cloud structures, storm structures, dust clouds, pollutants, forest burning and surface reflectance. Sites studied included the atmosphere above northern Europe, Indonesia and the south Pacific, Russia and Africa. Ground-based and aircraft instruments were also used to verify LITE data.

On mission day five the SPARTAN-201 free flying platform, making its second flight on the Shuttle, was released to collect data about the accel-

eration and velocity of the solar wind and to measure the Sun's corona. SPARTAN was retrieved after two days of data collection.

Various other middeck and payload bay experiments were also flown including a number of Get Away Special canisters. One payload bay experiment called SPIFEX collected data about orbiter reaction control system thruster firings to aid understanding the potential effects of thruster plumes on large space structures such as the Russian Mir space station and the planned International Space Station. The SPIFEX experiment was a 33 foot long extension to the orbiter's remote manipulator arm and was deployed in a variety of positions above the nose of the spacecraft and near the left orbital manoeuvring system pod. All preflight objectives were achieved.

Carl Meade and Mark Lee spent more than six hours outside Discovery

carrying out a spacewalk in which they tested a new manoeuvring unit backpack called SAFER. The lightweight device which was tested by both astronauts was flown as the prototype of a self-rescue device for astronauts who might become detached from their spacecraft.

The orbiter was diverted to a California landing following several KSC call-offs due to unfavourable weather with touchdown taking place at 5:12 pm EDT on 20 September.

STS-68: Endeavour

STS-68's first launch attempt on 18 August was halted at T-1.9 seconds when the orbiter computers shut down all three main engines after detecting an unacceptably high temperature in an engine turbopump turbine. As a result of this Endeavour was returned to the VAB to have all three engines replaced. The launch was rescheduled for 30 September when lift-off occurred on time at 7:16 am EDT.

STS-68 marked the second flight of the Space Radar Laboratory which had flown earlier in the year on STS-59. By flying the radar lab during different seasons it allowed scientists to compare changes between the two flights. Data were collected over the same locations as on the first flight but images were also obtained of an erupting volcano in Russia and several Japanese islands following an earthquake. The space radar on this flight also imaged a planned oil spill in the North Sea in order to test its ability to discern the difference between human-induced and naturally occurring ocean film.

Other payload bay equipment included five Get Away Special canisters, two of which held 500,000 commemorative US Postal Service stamps commemorating the 25th anniversary of Apollo 11. Middeck payloads in-

On board STS-68, Terence Wilcutt takes advantage of the weightless environment of space to juggle five cameras. A large format Linhof camera is on the left. The other cameras are handheld Hasselblads.

NASA



SPACE SHUTTLE

cluded the Commercial Crystal Growth experiment to study the dynamics of protein crystallization and CHROMEX-05, the fifth in a series designed to examine the effects of microgravity on plants.

Unacceptable weather in the KSC area resulted in Endeavour being diverted to Edwards Air Force Base in California where landing took place at 1:02 pm EDT on 11 October.

STS-66: Atlantis

Following a two-year refurbishment, Atlantis lifted off on the final 1994 mission on 3 November to carry out investigations of the Earth's atmosphere and the effects of the Sun and human activities on its chemical composition. Primary payloads aboard the orbiter were the ATLAS-3 instruments and the German-built SPAS free-flying platform.

ATLAS-3 was a complement of six international experiments located on a pallet in the orbiter's payload bay designed to study the Sun and map the Earth's atmosphere. The ATLAS missions are planned to fly regularly over a 10-year period to analyse the chemical and physical components of the atmosphere.

The free-flying SPAS satellite was deployed from Atlantis on 4 November by French astronaut Jean-Francois Clervoy. Carrying three infrared telescopes and other instruments designed to create a three-dimensional map of the flow of gases in the Earth's middle atmosphere the satellite spent eight days flying in formation with the Shuttle orbiter as it gathered data.

Tests were carried out with a middeck experiment called Heat Pipe Performance which involved applying specifically-measured amounts of heat to the various heat pipe designs flown, measuring the cooling capacity of the pipes and determining the limits of each design's operation. The crew found time to perform additional tests



STS-66 mission commander Donald R. McMonagle is seen at his station on Atlantis' forward flight deck back-to-back with payload commander Ellen Ochoa on the aft flight deck following completion of an operation with the Remote Manipulator System (RMS) arm.

NASA

beyond those originally planned. These tests were aimed at providing data on cooling systems for the next generation of spacecraft and the space station. Also onboard Atlantis were ten pregnant rats, the first pregnant mammals to fly aboard a US spacecraft, and part of an experiment to examine how weightlessness affects fetal development.

The successful retrieval of the German SPAS satellite, which had been trailing the orbiter by upwards of 50 miles for most of the flight, rounded off the mission. The rendezvous with SPAS was attempted using a new method in anticipation of the 1995 Shuttle-Mir dockings. Normally an orbiter approaches its target from the front, but on STS-66 Atlantis approached SPAS from below in order to avoid firing manoeuvring jets towards the satellite. On a larger space structure such as Mir or the Interna-

tional Space Station, solar panels could be easily damaged by such firings.

Atlantis returned to Earth on 14 November with a wealth of data collected by the atmospheric/solar energy instruments aboard, touching down at Edwards Air Force Base in California. The orbiter had been scheduled to land in Florida but the tropical storm 'Gordon' in the Gulf of Mexico forced the landing site to be moved. This was the fourth time in 1994 that a Shuttle landing had to be diverted due to unacceptable weather in Florida.

Acknowledgements

The writer would like to thank Kay Grinter and Ken Thornsley of NASA's Kennedy Space Center and Billie Deason and Debra Dodds of NASA's Johnson Space Center for providing material for this article.

The Shuttle's Year in Space - A Review of 1994 Missions.

Mission Designation	STS-60	STS-62	STS-59	STS-65	STS-64	STS-68	STS-66
Flight Number	60	61	62	63	64	65	66
Launch Date	Feb 3	Mar 4	Apr 9	Jul 8	Sept 9	Sept 30	Nov 3
Launch Pad	39A	39B	39A	39A	39B	39A	39B
Orbiter	Discovery (18)	Columbia (16)	Endeavour (6)	Columbia (17)	Discovery (19)	Endeavour (7)	Atlantis (13)
Flight Crew:							
CDR	Bolden	Casper	Gutierrez	Cabana	Richards	Baker	McMonagle
PLT	Reightler	Allen	Chilton	Halsell	Hammond	Wilcutt	Brown
MS1	Davis	Thuot	Apt	Hieb	Linenger	Smith	Ochoa
MS2	Sega	Gemar	Clifford	Walz	Helms	Bursch	Parazynski
MS3	Chang-Diaz	Ivins	Godwin	Chiao	Meade (EVA-2)	Wisoff	Tanner
MS4	Krikalev	—	Jones	Thomas	Lee (EVA-1)	Jones	Clervoy
PS1	—	—	—	Mukai	—	—	—
Max. Altitude (nm)	190	160	120	160	149	120	165
Inclination	57°	39°	57°	28.45°	57°	57°	57°
Landing Date	Feb 11	Mar 18	Apr 20	Jul 23	Sept 20	Oct 11	Nov 14
Landing Location	KSC	KSC	Edwards	KSC	Edwards	Edwards	Edwards
Flight Duration	8d7h10m13s	13d23h17m28s	11d5h49m23s	14d17h55m1s	10d23h49m57s	11d5h46m9s	10d22h34m2s
Primary Payloads	Wake Shield Spacehab-2	USMP-2 OAST-2	SRL-1	IML-2	LITE-1 SPARTAN-201	SRL-2	ATLAS-3 CHRISTA-SPAS

Key Years in the Space Race, 1966-1969

Soviet Lunar Dream that Faded

Diary Tells What Was and What Might Have Been

Excerpts from the diary of General Nikolai Kamanin published in the Russian magazine *Vozdushnyy Transport* in 1993 [1,2] shed further light on the Soviet manned lunar programme and in particular on the L-1/Zond programme.

Dual Launch Scenario

Surprisingly, the original L-1 flight plan, discussed during a 24 December 1966 meeting of the L-1 state commission, envisaged a dual launch scenario.

It was decided to launch the L-1 unmanned on Proton and subsequently send up the two-man crew on a Soyuz spacecraft, the reason being that the three-stage Proton rocket (UR-500K) earmarked to launch L-1 and its Block-D escape stage had not flown at the time.

Following docking with the L-1/Block-D combination in Earth orbit the crew would spacewalk to the L-1, following which the Block-D would boost the L-1 to the Moon and Soyuz would return to the Earth unmanned.

It was not until early June 1967, by which time the UR-500K had made two successful launches, that this plan was abandoned in favour of the single launch scenario on Proton.

A picture of cosmonaut Vladimir Komarov undergoing spacewalk training may be linked to the dual launch plan [3]. While Komarov was not supposed to perform extravehicular activity on the Soyuz-1/2 mission, it is known that in September 1966 he was selected for both the Soyuz and L-1 programmes [2]. Therefore he may temporarily have trained for a possible Soyuz/Zond spacewalk before being assigned to the Soyuz-1 mission.

Unmanned L-1 Launches

In December 1966 the official schedule called for four unmanned L-1 missions in the first few months of 1967 to be followed by the first manned flight in June 1967. Not surprisingly, many considered this schedule extremely unrealistic, including Kamanin who gave detailed accounts of most of the L-1 missions.

The Cosmos-146 mission in March 1967 achieved its goal of using the new Block-D upper stage to boost a prototype L-1 (code-named 7K-L1P) to escape velocity. The ship was "sent into the direction of the Moon" in Kamanin's words, but it is clear recovery was not intended. It is known from another source that the ship ended up in a highly elliptical Earth orbit [4].

Cosmos-154, another 7K-L1P, was launched on 8 April 1967, but got stranded in Earth orbit because the

BY BART HENDRICKX

Belgium

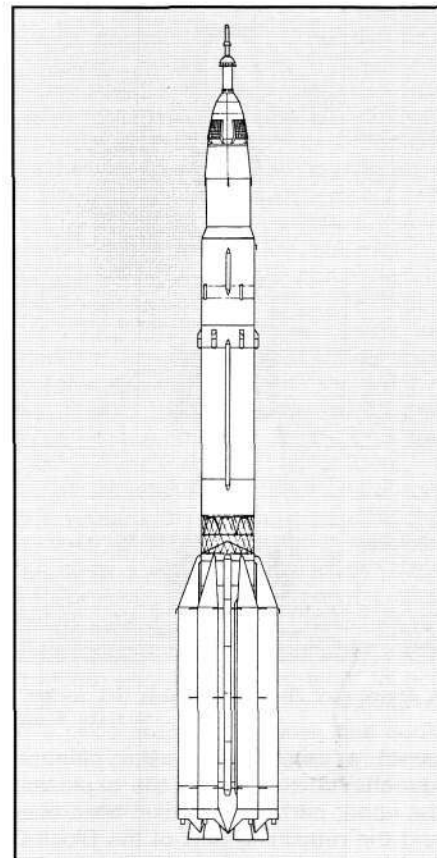
Block-D prematurely cast off its so called ullage motors (which are used to settle the weightless propellants in the partially laden tanks before ignition).

On the third launch in the early morning of 28 September 1967, the Proton lifted off with only five of its six first stage engines working and started veering off course one minute into the flight, eventually crashing 65 km from the launch pad (although the escape system safely pulled the L-1 away). It was later determined that a rubber plug had become lodged in a fuel line of the first stage engine during assembly at the factory.

The fourth launch, carried out in the early morning of 23 November 1967, failed when one of the four second stages did not ignite properly. Just four seconds later the rocket began tumbling out of control, causing the automatic control system to shut down the three other engines and activate the launch escape system. The Proton crashed 300 km from the pad and the L-1 vehicle "successfully" landed 80 km south-west from the city of Dzhezkazgan.

An earlier report suggested that the latter two L-1 vehicles were launched on trajectories away from the Moon, merely simulating a return to Earth from a high apogee orbit [5]. However, Kamanin explicitly states that the goal of the third mission was a lunar fly-around with a landing in either Kazakhstan or the Indian Ocean. The lunar Greenwich Hour Angle at the time of launch confirms this. No explicit mission objective is given for the fourth mission, but the lunar Greenwich Hour Angle at the time of launch was 238°, pointing to a lunar fly-around goal for this mission as well [6].

The next L-1 (Zond-4) was placed into a highly elliptical orbit away from the Moon, reaching an apogee of 330,000 km, but was deliberately blown up 10 to 15 km above the Gulf of Guinea after it failed to carry out its planned double-skip reentry to the Soviet Union and plunged into the atmosphere on a 20g ballistic trajectory towards an unplanned region.

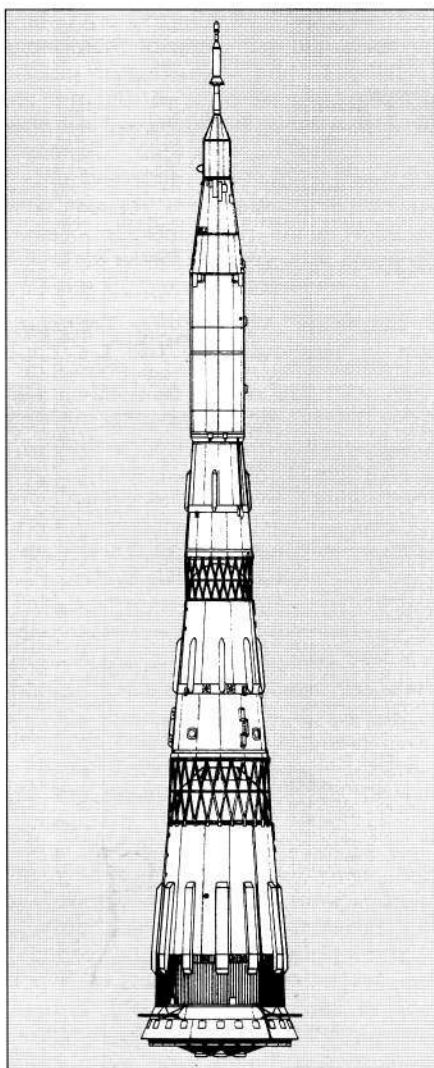


A drawing of the Proton rocket (UR-500K) with the L-1 payload stage. MICHAEL NAGEL

Kamanin strongly criticizes the decision to detonate the spacecraft (made by D. Ustinov and L. Smirnov) and says a landing attempt should have been made irrespective of where the ship was heading for.

The next mission, another lunar fly-around attempt, was launched on 23 April 1968, but during second stage operation the Zond's automatic control system suffered a short circuit and sent a faulty command to the second stage to shut down all its engines some 260 seconds into the flight. The L-1 vehicle was again safely ejected from the rocket.

Another L-1 launch planned for July 1968 had to be cancelled when the Block-D was seriously damaged on the launch pad. Kamanin says the Block-D oxidizer tank "exploded" (although it was unfuelled at the time), killing three launch pad workers. The accident is reported in the 15 July entry of the diary and took place



A drawing of the 103 m high N-1 rocket.
MICHAEL NAGEL

about a week before the planned launch. As a result of the explosion the upper part of the rocket tilted over and the remaining part of the Block-D and the L-1 "ended up on the service tower" in Kamanin's words. If the support tower had been rolled back, the Block-D and the (fully fuelled) L-1 would have come crashing to the ground and exploded. Consideration was given to lifting the L-1 from the rocket with a helicopter, but this was very risky. Unfortunately, the next diary entry is 10 September and it is not clear how this ordeal ended. Surprisingly, Kamanin says that only the third stage of the Proton suffered major damage and required replacement and that the L-1 could be used for a future launch. It appears however that the next mission (Zond-5 in September) used another vehicle.

Mention of Manned L-1

The published excerpts from Kamanin's diary do not confirm and even throw doubt on reports that a manned Zond mission to upstage Apollo-8 was considered, let alone attempted. On 9 November 1968 Kamanin writes that following the (partially successful) Zond-5 mission two more successful "technological launches" (unmanned

missions) were required to man-rate the L-1. One day later he says the first manned L-1 mission is planned for the "first half of 1969". On 26 November, about two weeks after the crash-landing of Zond-6, he writes that "for the time being we don't consider it possible to send people to [the Moon]". The next entry is 12 December with no mention or hint of a cancelled manned launch from Baikonur.

Block-D Role

Another Zond launch attempt took place in the morning of 20 January 1969 with an L-1 which Kamanin describes as a "technological vehicle", making it doubtful that it was the man-rated spacecraft that was supposed to be ready for launch in early December 1968. Anyway, things went wrong again. With just 25 seconds left in the second stage burn, one of its four engines shut down. The third stage ignited as planned and the L-1 could have been inserted into orbit, but the automatic safety systems on L-1 were programmed to activate the emergency escape system whenever an engine failed, which is exactly what they did.

The Proton's three stages were not powerful enough to boost the L-1 vehicles and their Block-D upper stages into orbit. Shortly after third stage separation the Block-D used to be fired for about 100 seconds to place itself and the Zond into parking orbit. Block-D therefore performed a dual role: orbit insertion and translunar injection. It is known that Block-D was also used for orbital injection on the Luna sample return, Mars 2-7 as well as Phobos 1 and 2 missions. It would therefore seem that the use of Block-D as an orbit insertion stage was standard procedure for all Proton-launched deep space missions (including Venera and Lunokhod).

Reentry Test

The Zond-8 mission in October 1970, flown in support of the N-1/L-3 programme, tested a reentry path over the Northern hemisphere with a splashdown in the Indian Ocean. Mishin favoured this option for the return of the lunar orbiter (LOK) descent capsule, despite the successful double-skip reentries to Soviet territory performed by Zond-6 and Zond-7.

Lunar Landing Scenario

Further information on the N-1/L-3 manned lunar landing programme has come from the Videokosmos space information centre in Moscow [7]. While the L-3 flight scenario has been described in detail by other sources, it now turns out that the original manned lunar landing plan envisaged no less than four launches, two by Proton and two by N-1.

The information was provided to Videokosmos by Vyacheslav Filin, an NPO Energiya veteran who used to

work on the Soviet lunar module (LK) and who is also the author of a book on the LK. It seems the Soviets were prepared to go to almost absurd lengths to ensure the safe return of their lunar module pilot. The plan was to launch an N-1 carrying an unmanned back-up lunar module (Russian acronym LKR) to the Moon one month prior to the manned N-1 launch. The idea was that the lunar module pilot could use the LKR to lift off from the Moon in case his own lunar module suffered damage during landing.

But that was only part of the plan. In order to reconnoitre the landing sites of both the back-up and prime lunar landers the Soviets planned to send two remotely controlled rovers to the designated landing spots for the LKR and LK one month before the unmanned N-1 launch. Code-named Ye-8, they were precursors of the later Lunokhod rovers according to the Videokosmos article and would have been launched separately on two Proton/Block-D boosters with an interval of several days. Prior to that the landing spots would have been extensively photographed from lunar orbit by unmanned probes designated Ye-8LS (two of these, Luna-19 and Luna-22, were actually flown in 1971 and 1974). If that were not enough, the unmanned N-1 in addition to the LKR would have carried an unmanned lunar orbiter (LOK) that would have made additional high-resolution photographs before returning to Earth.

Radio beacons installed on the Ye-8 rovers would have guided the back-up LKR to the planned landing site. Following landing, the lunar rovers would have approached the LKR and photographed it from all sides. Only if ground controllers were convinced that the LKR was in fine shape, would the go-ahead have been given for the manned N-1 launch. Also guided by the Ye-8 beacons, the manned lunar module would have landed as close as possible to the back-up LKR following which it in turn would be photographed by the rovers. If the manned lunar lander was undamaged, the pilot would have made a two-hour moonwalk and returned to his orbiting colleague in the LOK after a total surface stay of 6 hours. If the manned LK had suffered damage preventing a safe liftoff, the pilot would have transferred to the back-up lander.

Apparently, the Russians were not confident they could land the two lunar modules within walking distance from one another. Therefore, the Ye-8 lunar rovers were equipped to transport the cosmonaut from the prime to the back-up lander. They were outfitted with oxygen tanks to which the cosmonaut could hook up his Krechet moonsuit. The cosmonaut would have been standing on a small platform attached to the front side of the rover, very much resembling someone driving a railway handcart.

Sample Return Missions

It would seem from this that the Lunokhod 1 and 2 rovers, applauded at the time by the Soviet propaganda machine as examples of cheap unmanned lunar exploration, had their roots in the manned lunar landing programme. It is unclear however how much their design differed from that of man-related rovers and what the Ye-8 designator actually stands for. General Kamanin also talks about Ye-8 rovers in his diary, but does not link them to the manned programme. He mentions Ye-8 while describing a meeting of the Military-Industrial Commission (VPK) held on 30 December 1968 to discuss a Soviet response to the success of Apollo-8 [1]:

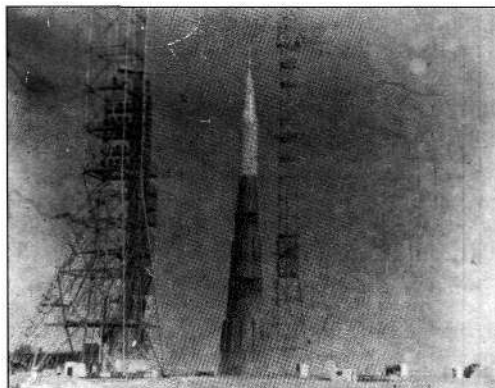
"At the meeting of the VPK it was decided to send to the Moon the automatic ship Ye-8-5. The Ye-8 series of automatic vehicles of chief designer Babakin are capable of landing on the Moon and deploying a self-propelled rover which can move about on the lunar surface. Ye-8 is a further development of Luna-9 and Luna-13 [earlier code-named by Kamanin as Ye-6], while Ye-8-5 is a further development of the as yet unflown Ye-8. The automatic stations Ye-8-5 have the task of landing on the Moon, collecting lunar soil and returning it to the Earth. In itself the flight is interesting, but it is a far cry from what Apollo-8 achieved."

It is known that all the third-generation Luna probes (sample return missions, Lunokhods and Luna 19 and 22 orbiters) used a common descent/orbit insertion stage and differed only in the payloads they carried. From Kamanin's comments it would seem that the rover version was designed first, although it is uncertain whether its original purpose was lunar module support, unmanned exploration or both (the term Ye-8 may be a common name for the lunar module support version and the Lunokhod version).

The Ye-8LS orbiters retained the basic "bathtub" design of the Lunokhods minus the wheels and lid and therefore are likely to be outgrowths of the rover. The Ye-8-5 sample return probes were then conceived later mainly as a propaganda response to Apollo. Indications are that as with the US Ranger, Surveyor and Lunar Orbiter probes, the Luna vehicles were mainly intended to pave the way for manned lunar landings.

Manned Lunar Programme that Never Took Off

Kamanin describes an earlier undisclosed Proton launch failure on 19 February 1969 which he says carried a "Ye-8 lunar rover". The Proton lifted off and exploded 40 seconds into the flight, crashing 15 km from the launch pad. Kamanin does not elaborate further on the payload, but according to Videokosmos' Sergei Shamsutdinov evidence now indicates this was a lu-



An N-1 booster poised for launch on one of the two pads at Baikonur.

nar module support rover.

Interestingly, this failure took place just two days before the launch of the first N-1 rocket, which carried an 7K-L1S orbiter to photograph proposed lunar landing sites [5]. The close timing of the two missions may be solely tied to the lunar launch window, but a link between the two is not impossible. Perhaps the 7K-L1S could have used its high resolution cameras to try and spot the Ye-8 on the lunar surface. In any case, if both missions had succeeded, they would have stolen much of the glamour from Apollo-9 (launched in early March 1969), in the same fashion as the second N-1 and Luna-15 could have at least partially diverted the world's attention from Apollo-11 in July 1969.

The Videokosmos article says that original plans called for the construction of at least 16 N-1 boosters :

- The 1L and 2L vehicles were mock-ups intended for assembly and launch pad tests.
- The 3L, 5L and 6L vehicles were mainly intended to test the N-1 and its upper stages. 3L and 5L (launched 21 February and 3 July 1969) carried live Block-G and Block-D stages and L1S ships. According to new information from Videokosmos' Sergei Shamsutdinov, the L1S would have been placed into lunar orbit by Block-D and not by the ship's own DOK engine unit as earlier reported (5). 6L (launched 27 June 1971) had live Block-G and Block-D stages and a mock-up lunar lander and lunar orbiter.
- The 7L vehicle (launched 23 November 1972) carried a mock-up lunar lander and a real LOK lunar orbiter. The latter would have been placed into lunar orbit and returned to Earth.
- The 8L and 9L vehicles would have carried real lunar landers and lunar orbiters. The purpose was to fly the entire L-3 mission in an unmanned mode (including landing on the Moon).
- The 10L vehicle could have carried the first Soviet cosmonaut to the lunar surface. An alternative plan was to fly an Apollo-10 type dress rehearsal mission which called for the lunar module pilot to spacewalk from the LOK to the LK and back in lunar orbit, before the LK made an automatic landing and return to the orbiting LOK. If this mission went

as planned, the first manned lunar landing launch would have been performed by the 11L vehicle. At least four to five follow-up landing expeditions (up to vehicles 15L or 16L) were originally planned.

The 4L vehicle, absent in this flight plan, was taken out of service for modifications following the 3L failure in February 1969 and was then kept in storage for launching an LKR back-up lunar module. It could therefore have been launched one month before the 10L or 11L vehicle, depending on which of the two was chosen for the first manned landing.

Considering the high cost, it would seem that the quadruple launch scenario described earlier was considered for the first manned landing only. If the first landing was a success, no further back-up lunar landers would have been required for subsequent missions. Although not confirmed in the Videokosmos article, one could speculate that the Ye-8 rovers or modified versions would have gone on to fulfill the same role as the US Lunar Rovers on the Apollo-15, 16 and 17 missions, namely to expand the moonwalker's area of exploration.

The simultaneous placement of two N-1 rockets on adjacent pads in the summer of 1969 (one the 5L vehicle, the other a mock-up) has earlier been interpreted as a simulation of a dual N-1 launch campaign [8]. The LK/LKR plan called for two N-1 launches within a month (dictated by the lunar launch window) and if this required activity on two pads at the same time, one could wonder in what way the destruction of pad 1 in the 5L explosion affected those plans.

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Claude Nicollier. ESA/NASA

Two ESA Astronauts on Shuttle Tether Mission

BY ROLF H. SCHOEVAART
The Netherlands

For the first time in manned space flight history two European Space Agency astronauts will fly together as mission specialists on the Space Shuttle.



Maurizio Cheli. NASA

On 27 January 1995 NASA announced the assignment of Claude Nicollier from Switzerland and Maurizio Cheli from Italy for flight STS-75 in early 1996, which will see the second deployment of the joint NASA/ASI (Italian Space Agency) Tethered Satellite System (TSS).

Cheli will be MS-2, the crewmember in the aft centre seat on the flight deck of the shuttle, who supports the commander and pilot during the ascent and descent phases of the mission.

The 1.6 m diameter Italian-built TSS satellite is scheduled to be deployed on the end of a 20 km conductive tether to study the electrodynamic effects of moving such a tether through the Earth's magnetic field and to test techniques for managing tethered spacecraft at great distances.

During the 13 day mission the crew will also conduct advanced scientific investigations, similar to those planned aboard the International Space Station, using the US Microgravity Payload (USMP).

The commander of the STS-75 crew Andrew M. Allen will be joined by pilot Scott J. Horowitz and two more mission specialists: Franklin R. Chang-Diaz (payload commander) and Jeffrey A. Hoffman and Italian Space Agency payload specialist Umberto Guidoni.

Umberto Guidoni (left) shaking hands with Franco Malerba during the Terminal Countdown Demonstration Test of the first Tethered Satellite mission (STS-46) in 1992. NASA



specialist Umberto Guidoni.

Allen, Chang-Diaz, Hoffman and Nicollier also flew on the first TSS mission (STS-46) in July/August 1992 during which the satellite was only partly deployed to a distance of about 274 m. Guidoni was the alternate payload specialist for that flight and experiment project scientist.

There will be no backup payload specialist for the STS-75/TSS reflight. Originally Franco E. Malerba the payload specialist on STS-46 was a candidate for that position. However in 1994 he was elected as a Forza Italia member in the European Parliament. His political duties prevent him from taking part on account of the one year period of preparation for a shuttle flight demanded by NASA.

The selection and training of a new candidate payload specialist was considered too expensive. That is why after negotiations between NASA and the ASI the decision has been taken that one of the mission specialists will also have the role of alternate payload specialist. Maurizio Cheli will be a logical choice for this position. The solution is not new, because in 1984 during the Shuttle 41D mission Judith A. Resnik had a similar task supporting payload specialist Charles D. Walker for the EOS experiment. ■

Spaceflight Crossword

No. 20

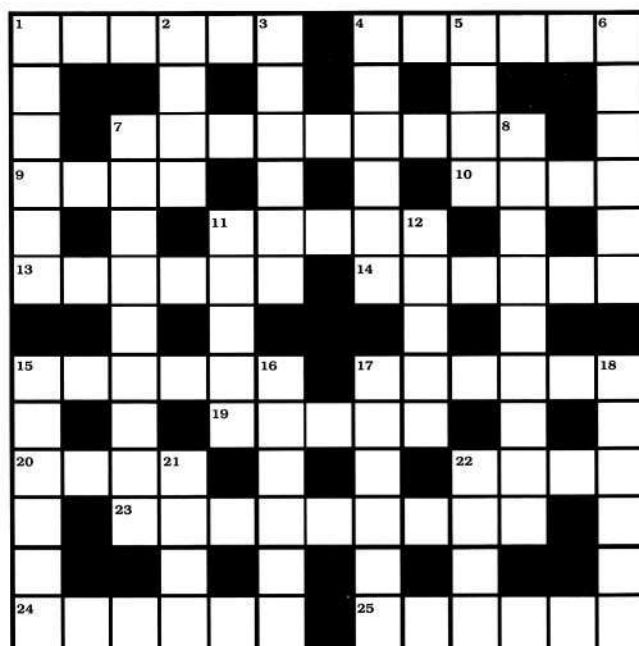
ACROSS

1. German astronomer with a comet and a paradox
4. Equatorial launch site
7. Constellation that includes north celestial pole (4,4)
9. Electrically charged atoms
10. He was in space with Krikalev
11. Simplified aid for EVA rescue
13. Pertained to the USSR
14. Grooved spirally
15. Ring
17. Obstructs
19. Asparagus
20. Asteroid mission
22. Degree of hotness
23. Place of departure for rockets (6,3)
24. Flow
25. — rope-trick

DOWN

1. Planetary paths
2. Hearing devices
3. US oceanography satellite
4. Planetary astronomer after whom NASA named Airborne Observatory
5. Flying saucers
6. Without stipend
7. Cosmic
8. Mirrored
11. Ratifies
12. Narrow valley on the surface of the Moon
15. Boats to paddle
16. A person or character whose name is used as a title
17. Mission specialist on first shuttle fully devoted to a military payload
18. Planet
21. Scarce
22. Difficult to scratch

Solution will appear in the May issue.



Solution to Crossword No.19.

ACROSS: 1. Miranda; 5. Water; 8. Nadir; 9. Compass; 10. Hydration; 12. Sol; 13. Crater; 14. Strove; 17. Duo; 18. Wollaston; 20. Noisome; 21. Stand; 23. Ensur; 24. Optical.

DOWN: 1. Month; 2. Red; 3. Narrate; 4. Arctic; 5. Woman; 6. Transport; 7. Resolve; 11. Draconids; 13. Cadence; 15. Transit; 16. Albedo; 18. Whole; 19. Nodal; 22. Arc.

New Position for Ulf Merbold



Dr Ulf Merbold ESA

After his successful EuroMir-94 space flight, the ESA astronaut Ulf Merbold has been appointed Acting Head of the Astronaut division of the European Astronauts Centre (ESA-EAC) in Cologne (Germany) until the end of 1995. He succeeds Dr Franco Rossitto.

Merbold will be responsible for astronaut selection, crew assignment, assignment of astronaut tasks and their support, safety and medical surveillance. In spite of his new job he will be eligible for future space missions and will perform all tasks necessary to maintain his active status.

During EuroMir-95, the next flight of an ESA astronaut (Christer Fuglesang or Thomas Reiter) to the Russian Mir Station (from 22 August 1995 - 4 January 1996), Dr Merbold will have several duties in the Operations Control Centre at Oberpfaffenhofen (Germany).

ROLF SCHOEVAART

Microgravity Loss for ESA

A Soyuz launcher carrying Foton-10, a retrievable capsule with a set of ESA biological experiments in a Biobox incubator was launched on 16 February from Plesetsk. After a safe landing in Russia a recovery transport helicopter dropped the capsule in bad weather severely damaging the capsule and its contents.

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The British Interplanetary Society

SPACELINE

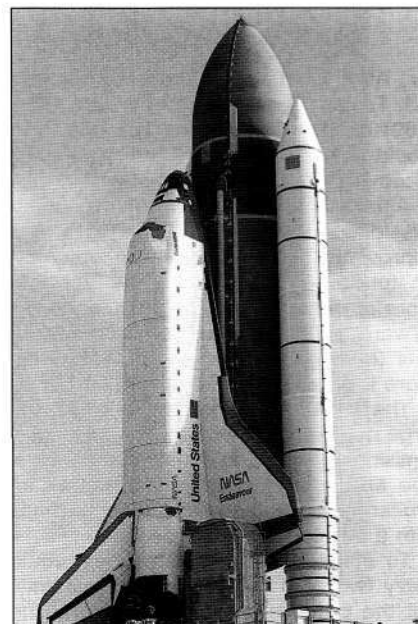
STS-67: Shuttle Launch Goes Ahead Despite Weather Doubts

The launch of Endeavour at 1:38 am (0638 GMT) on 2 March went ahead despite misgivings over the weather but suffered a delay of 1 minute 13 seconds due to a potential problem with a heating system. A back-up heater was utilised and the countdown proceeded.

The seven astronauts aboard Endeavour, including four astrophysicists, will spend 15 and a half days in space training three ultraviolet telescopes on stars, galaxies, quasars, the Moon and Jupiter. Astronomers have a list of some 600 stars, galaxies and quasars including 11 white dwarfs to select from during the flight. Details of the ASTRO-2 payloads and crew members appeared in *Spaceflight*, February 1995, p.64.

The longest shuttle mission to date is Columbia's 14 day 18-hour mission last year and Endeavour should exceed this by 19 hours. The crew is working in two shifts around the clock. The Blue Team will be on duty for the morning while their fellow crew members, called the Red Team, sleep. The Red crew members will take over duties at about 10:52 am.

Endeavour is in an orbit with a high point of 190 nautical miles and a low point of 188 nautical miles, completing one orbit every 91 minutes at an inclination of 28.45 degrees.



STS-67: a close-up of Endeavour rolling to Pad 39A on 8 February 1995 as the clouds clear and the early morning sun shines on the orbiter.

PETER GUALTIERI/WEST KENTUCKY NEWS

Endeavour is scheduled to land in Florida on 17 March, at 3:10 pm (2010 GMT).

Mir Update: Manned and Unmanned Launches

At 1648 GMT on 15 February the Russians launched the unmanned cargo spacecraft Progress M-26 to deliver supplies to the Mir orbital complex. This was the first launch from the Baikonur cosmodrome of 1995 and the 361st from the "Gagarin Launch Complex" in 40 years since the cosmodrome began operations. (The complex was originally designed for only 10 launchings, according to Russian sources.)

The craft carried over 2 tonnes of supplies for the EO-17 crew of Viktorenko, Kondakova and Polyakov, who, just over a week earlier had been involved in the historic rendezvous with the American shuttle orbiter Discovery.

The M-26 cargo spacecraft docked with Mir's rear Kvant port recently vacated by the Progress M-25 craft at 1822 GMT on 17 February. The three cosmonauts began unloading the cargo delivered almost immediately.

Amongst the supplies was 100 kg of equipment for use by the American medical doctor and astronaut Norman Thagard who will be launched on 14 March with two Russians (Dezhurov and Strekalov) as the EO-18 crew to the complex. Dezhurov is a rookie and both Strekalov and Thagard have four missions in space each to their credit. However,

the bulk of the American equipment - about 1000 kg - is to be delivered by the much-delayed Spektr science module due for launch on 11 May 1995 near the end of the American's stay on the complex.

The EO-18 crew will be the focus of intense work over the coming months with up to five EVAs, four re-dockings of the Kristall module, and dockings of the Spektr module and the American shuttle orbiter Atlantis which will deliver a two-man Russian crew (Solovyov and Budarin) to the complex to become the EO-19 crew. Thagard is to set a record duration stay for an American citizen of 90 days during the flight of EO-18. The next American to be launched by the Russians to the Mir complex for an extended stay will be either John Blaha or Shannon Lucid as a part of the EO-21 crew due for launch on Christmas day 1995.

NEVILLE KIDGER

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-71	10 June	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	22 June	Discovery	5 Days	TDRS-G	28.5
STS-69	20 July	Endeavour	10 Days	WSF-2, Spartan 201-03	28.5
STS-73	21 September	Columbia	16 Days	USML-02	28.5
STS-74	26 October	Atlantis	6 Days	Second Mir Docking	51.6
STS-72	30 November	Endeavour	9 Days	Retrieval of SFU (Japan launch), Spartan/OAST free flyer	28.5



Readers Write

Space Exploration

Sir, After reading the letter by Richard L.S. Taylor (*Spaceflight*, February 1995, p.69) on the Discovery Pluto mission I would like to put forward an idea for the Discovery concept as a whole.

Although a programme of five or six missions in four to five years is a vast improvement on the old days a way must be found to make them cheaper and more numerous. What I would like to put forward is that some sort of Multi-Purpose Bus (MPB) is developed to allow even more low cost exploration to take place.

The MPB would be mass produced in large numbers and would allow easy 'customising' by bolt and clip-on components. The MPB could be flown either as an orbiter/flyby vehicle or a lander perhaps with a payload of micro-rovers.

To start with the MPB probes would carry two or three science instruments, but the process of still further shrinking electronics could bring it up to perhaps five.

Such a programme would lead to massive spin-offs for Earth such as cheaper, smarter computers. Such machines could even lead to the 'Holy Grail' of robotic space flight - that of self-replicating robotic factories and probes. Perhaps this could be NASA's next big challenge after Alpha's completion.

So, the sooner we design *small*, the sooner we can have the first robotic factory on the Moon churning out helium 3, O'Neill colony components and many other useful items required if we are to colonise and explore space.

E. PHILPOTT
South Wirral, UK

Space Log Dilemma

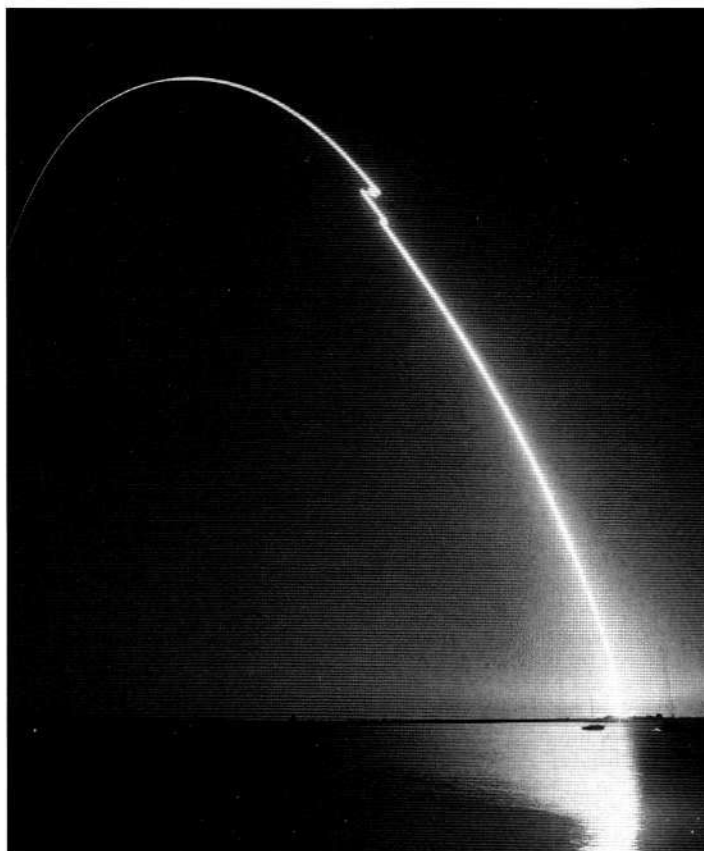
Sir, Space-history statisticians are about to encounter a problem in the compilation of their records of human space flight duration. Until now it has been customary to attribute individual totals to the cumulative totals of the country of origin of the spacecraft, irrespective of the nationality or affiliation of the astronaut/cosmonaut.

The Mir/Shuttle missions, in which astronauts and cosmonauts are launched in a spacecraft of one nation and return to Earth in a spacecraft of a different nation, will make such a distinction difficult, if not impossible. Now might be the appropriate time to abandon the practice and consider only the cumulative totals of particular individuals for record purposes.

As of the end of 1994 the ratio of Russian (including the former USSR) to American human space flight duration stood at 2.9:1, a value that had remained constant throughout the year. This comparison, a relic of the "cold war" and the "space race", may no longer be relevant in an era of *detente* and international co-operation. Members' comments are invited.

MARCIA SMITH
GEOFF PERRY
The Kettering Group

Spectacular Night Launch



Sir, As a member of the British Interplanetary Society, I have a particular interest in the American Space Program and seldom miss an opportunity to view a launch from my observatory or at the Cape itself.

The night launch of the Space Shuttle Discovery STS-63 on 3 February was one of the most spectacular night launches I have ever witnessed!

My friend and colleague, Jeffrey Pettitt, got and even better view from Titusville, Florida (about 10 miles from the Kennedy Space Center) and captured the enclosed view at 12:22 am (local time) on that date. He used a 28 mm f/1.8 lens set at f/11 for this 4-minute exposure to capture on film the flight path of the Space Shuttle. He used Kodak Gold (ISO 200) Gold print film and also managed to record steam va-

pours rising from the launch pad in the lower right of the photograph! The water in the foreground is Florida's famous Intercoastal Waterway which extends along the entire coast of the Sunshine State.

The zig-zag phenomena was caused by a shock wave 50 seconds into the flight. The resulting Earth tremor slightly vibrated the camera tripod. A sonic boom and "crackling" could be heard moments afterwards from my observatory some 60 miles Northwest of the launch pad! This is not always so when the wind is in another direction.

DONALD F. TROMBINO
Davis Memorial Solar Observatory
Florida, USA

Animals in Space

Sir, I refer to the recent correspondence in regard to animals in space and in particular to the French cat Félicette. Your correspondents Harvey Duncan and E.T. Pugh (*Spaceflight*, June 1994) both refer to the cat as "Felix", while the former mentions that the animal was a "tomcat". Both Mr Duncan and the stamp illustrated are incorrect in this respect, and I agree with correspondent P. Jung (*Spaceflight*, January 1995) that the cat's name was Félicette (Felicity) - a female.

I have been compiling a book on animal space flights and I had the unique opportunity to discuss this and other animal space flights with Russian Academician Dr Oleg Gazenko - one of the doyens of early Soviet bioastronautics - at the Association of Space Explorers' Congress in Vienna in 1993. When I showed him a photo of the cat in question, notated "Felix", he carefully explained that it was

named Felicity, and was a female.

On a separate question, he informed me that Sputnik II (November 1957) suffered a problem with the separation of the second stage which caused a loss of insulation and sent temperatures soaring to 40°C in the capsule containing the dog Laika. This caused her to die soon after of heat exhaustion, following what must have been considerable anxiety. Pioneering cosmonaut Vitaly Sevastyanov later confirmed these facts with me at the same Congress. Most published works state that Laika died several days after launch when her air ran out, while others say she died of a fatal injection given in orbit, as she was never destined to return to Earth. It seems the truth is far less palatable.

COLIN BURGESS
Sydney, Australia

Man and the Universe

Sir, In his *Zones of the Future* (*Spaceflight*, June 1994, p.213), Dr McLaughlin seems to be implying that all of human progress, achievement, etc will come to a grinding halt within the next few centuries. Reading this comment, I am reminded of the 19th Century head of the US Patents Office, who petitioned Congress for his office to be dissolved on the grounds that 'everything that could be invented had been invented'.

In the course of his article, Dr McLaughlin refers to Martin Harwit as saying that astronomy would become an exhausted field of study, in the same way as our knowledge of the physical geography of the Earth apparently is. Whilst I am not in a position to give a definitive statement on this, I suspect that there are few experts who would agree that we know all that there is to know about the structure of the Earth, however thorough our knowledge of the surface may be. I find the idea that, in a few centuries, we will have 'placed' every star, cluster, galaxy etc so carefully as to require no further study in that area quite staggering. But even if we did, it would hardly represent the end of all our researches into the various properties of the stars, planets, etc (and if life turned out to be widespread, that would greatly increase the range of information to be obtained). I refer to the late J.B.S. Haldane's comment about the 'universe not only being stranger than we imagine, but stranger than we can imagine'.

Dr McLaughlin states that a mathematically precocious Neanderthal would be unable to predict even the nature of the challenges facing us today. I would suggest that that analogy might be applied to Mr Harwit's belief concerning astrophysics to indicate that there may be whole new fields of research awaiting us, as yet completely unknown.

The idea of universal literacy is a recent major innovation. If you had approached a medieval monk and told him that one day the whole population would be able to read, with all that that implies, he would probably have considered you raving mad. If you had told him that Man could reach the point where he could store a copy of the complete recorded 'works' of mankind in a single house, he would have considered you worse than mad. The late Professor Bronofski, in his 'Ascent of Man', went into the subject in some detail, showing how, despite all the errors, blind alleys, and failures, there has been a movement upwards.

Man is, of course, the least 'pre-programmed' creature of all, having to spend years learning basic skills to 'fit in' civilisation. Since our cerebral makeup is so 'rough and ready', with much of it having to be 'picked up as you go along', it naturally leads to various forms of friction, inaccurate reasoning and more general failures. On the other hand, it also gives us the ability to go from, for example, designing, building and operating a coracle to designing, building and operating a Space Shuttle, and (perhaps) to designing, building and operating a star ship. A perfectly 'well-adjusted' society would not change.

I find it rather odd that Dr McLaughlin should, at one point, argue for mankind

Saturn V/Apollo Information Sought



Former astronaut Robert L. Crippen, Director of the Kennedy Space Center (seated) signs an agreement for the Restoration of the Saturn V launch vehicle with Dr Martin Harwit, Director of the National Air and Space Museum.

NASM photo by CAROLYN RUSSO

Sir, An important and historic agreement was recently signed between Dr Martin Harwit, Director of the Smithsonian Institution's National Air and Space Museum and Robert L. Crippen, (now retired) Director of NASA's Kennedy Space Center in Florida. The agreement allows for the restoration and movement of one of the three remaining Saturn V launch vehicles.

The Saturn V on display at the Kennedy Space Center is the same type of rocket that was used to carry astronauts to the Moon during Project Apollo. At 363 feet long, the Saturn V was - and remains - the world's largest rocket. The rocket, which has been on display outside and near the Vehicle Assembly Building (VAB) since the mid-1970s, is on a long-term loan to the Kennedy Space Center from the National Air and Space Museum. It will be the largest artefact ever restored for the Air and Space Museum.

The restoration will be carried out in conjunction with the construction of a new, multi-million dollar visitor's centre called the Saturn V/Apollo Center in which the rocket will be displayed and inter-

preted. Costs of the construction of this facility as well as restoration and moving of the Saturn V will be paid from revenues of the public visitor programme at the Kennedy Space Center.

The rocket consists of a first stage test vehicle known as the S-IC-T, a second stage (S-II) which may have been intended for the cancelled Apollo 18 mission, a third stage used for facilities testing (S-IVB-500F), and a boilerplate spacecraft known as BP-30.

As the Smithsonian Curator responsible for this rocket, I am seeking information on these stages and the spacecraft. Information can be passed to me at the address of the *Spaceflight* Office.

The other Saturn V's are located at NASA's Johnson Space Flight Center in Houston, Texas and at the Alabama Space and Rocket Center at NASA's Marshall Space Flight Center in Huntsville, Alabama.

FRANK H. WINTER
National Air and Space Museum
Curator, Rocketry

becoming completely static and, at another, express support for a theory which suggests the total collapse of civilisation due to our mental incapacity - surely, the two ideas are in total opposition to each other.

Rather ironically, I do agree, to a certain extent, with Dr McLaughlin's comments about the growth in bio-engineering and computing initiating changes in the future development of the human species. However, I see those changes as widening the opportunities open to us, in much the same way as the space programme does, and it distresses me to know that someone with Dr McLaughlin's limited view of our future is associated with an organisation - the JPL - which is supposed to be expanding mankind's horizons.

P.W. DAVEY
Dorset, UK

The author replies: I admire Mr Davey's enthusiasm, but I am puzzled by this reading of my text. My (tentative) forecasts were two in number: first, that the social/cultural aspect of our species would remain relatively unchanged; second, that our technological growth would be so rapid that it would move us from *Homo sapiens* to the status of being another species altogether.

The "collapse" theory of civilisation to which he alludes was included in my discussion but not endorsed.

I fail to see the contradiction which Mr Davey finds, and I also fail to see how the forecast of rapid technological growth is incompatible with the conduct of a space programme.

WILLIAM McLAUGHLIN
Jet Propulsion Laboratory
Pasadena, California

Visit to Baikonur - Launch Site of Soviet Lunar Programme and Energiya-Buran

Sir, I read with great interest Theo Pirard's report about the Baikonur Cosmodrome published in *Spaceflight*, January 1995, p.2.

I visited the cosmodrome myself with a group of eight space enthusiasts from Germany, Austria and the USA on 17-20 September 1994. The tour was excellently prepared and conducted by the Russian Space Forces (VKS), which is the military unit responsible for all launch activities of Russian carrier rockets (excluding the Start missile, which is operated by the Strategic Rocket Forces, RVSN). We visited the facilities of Proton, Soyuz and an Energiya-Buran Pad and were deeply impressed by the kindness and openness of our military companions.

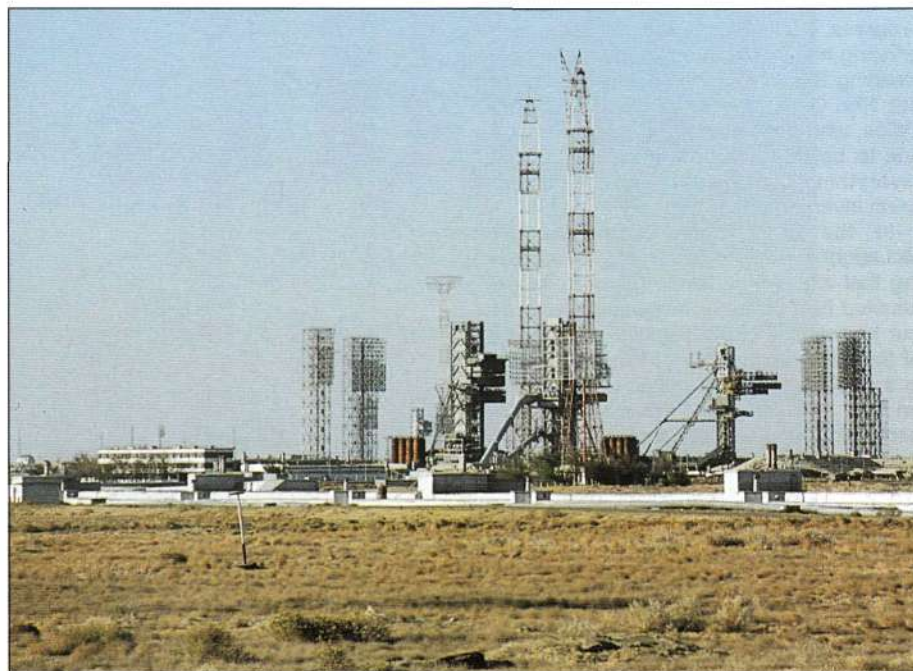
We were told about the Nedelin accident on 24 October 1960 during launch preparations for the maiden flight of a new ICBM R16 developed by Yangel. In contrast to Theo Pirard we were told that the second accident with another R16 missile or its modification took place two (not three) years later on 24 October 1962. The seven technicians were killed by toxic gases from the leaking missile.

Every building and launch site in Baikonur and Leninsk has its own identification number which was given to it when it was built. This means that older buildings have low numbers and more recent buildings have higher ones.

Most launch complexes consist of two pads. The Russians call them the Left and Right Pad (Levy Start, Pravy Start) in contrast to American nomenclature. (For instance Pad 39A and 39B of Complex 39.)

A list of buildings and facilities in the Baikonur cosmodrome and their numbers is appended.

STEFAN WOTZLAW
Dessau, Germany



A distant view of Energiya-Buran Complex No. 110, Pravy Start (Right Pad). It has not been used for any Energiya mission to date. In 1969 the pad was destroyed during the launch failure of the Moon rocket N-1 5L.

STEFAN WOTZLAW



Our group with Russian companions on the Left Pad of Complex No. 110.

STEFAN WOTZLAW

Site No.	Building/Facility
2	Gagarin's Start (Gagarin Pad), built originally in 1955 for launching the R7 missile and Sputnik, later Vostok manned capsules, now Soyuz TM manned spacecraft. Sometimes referred as Pad No. 1. Primary pad for launching Soyuz launch vehicles (manned and unmanned).
2B-1/ 2B-1A	Assembly building for Soyuz TM and Progress M spacecraft not far from Gagarin's Start. First used in 1975 for the Apollo-Soyuz Test Project.
3	Liquid oxygen, liquid nitrogen plant KAZ.
4	Tracking station Vega.
9	Tracking station Saturn.
31	Second Soyuz Pad, 9 kilometres east from Gagarin's Start. Built in 1961 as supplement for launching manned and unmanned launch vehi-

Site No.	Building/Facility
	cles Soyuz, Molniya, Vostok.
42	Zenit assembly building.
45	Zenit launch complex with two launch pads. One pad was destroyed during a lift-off accident and never rebuilt.
49	Second assembly building for Soyuz and its payloads, associated to complex No. 31.
81	Launch complex for Proton with two pads. Built in 1964 for launching loop around the Moon missions (programme L-1).
90	Tsiklon-M launch pad.
92A	Tsiklon-M assembly building.
95	Assembly building for the Proton launch vehicle. (Note that sometimes we were told that the Proton assembly building was No. 92).

Site No.	Building/Facility
110	Energiya-Buran-Complex with two launch pads, 800 m apart. Originally built for the N1 Moon rocket.
113	Energiya village with apartments, technical facilities and administrative buildings.
130	Energiya Assembly Building, formerly used for the N1.
200	Second Proton launch complex with two pads, built in 1976.
250	Single Energiya launch pad, approximately 4-5 kilometres north from complex No. 110, used for static test firing and Energiya's maiden flight. Also compatible with the Energiya-M carrier rocket.
251	Airfield "Anniversary" used for Buran shuttle landing and large cargo aircraft such as VM-T Atlant and AN-225.

Deceased Cosmonauts/Astronauts

Sir, The list of deceased cosmonauts/astonauts which appeared in the January 1995 issue of *Spaceflight* provided useful information, but it is not easy (mainly for younger readers) to identify a particular name with a particular space programme.

If one looks for names like Rogers, Wood, Adams, Lawrence and Taylor, which appear in the list, in the NASA astronaut lists he will not find them. The first two astronauts were members of the USAF Dyna-Soar programme and the others were selected for the military Manned Orbiting Laboratory (MOL) programme and none of them flew in space because of the premature cancellation of both programmes.

Even more confusing is the situation with the Soviet/Russian cosmonauts. Selected trainees were not registered as cosmonauts as this title belonged (and still belongs, I think) only to those who have flown in space. Trainees who left the programme (for any reason) without flying in space were "forgotten" and their names did not appear in public. The only exceptions were the Apollo-Soyuz and other international missions. Then perestroika opened the files and removed the secrecy partially.

We have many lists of "all" Soviet cosmonauts now, but I personally have not seen two identical ones. The same name can be found under several different groups (i.e. programmes) according to the author of the list.

I would be very grateful to anyone who could finally provide a really realistic and "official" list of all Soviet cosmonauts (including all those who have not flown) divided into groups according to selection date and occupation (Air Force, civilian) with the date and reason for resignation or cause of death, etc.

Maybe I am too optimistic, but I hope it will not take long before we finally have THE list of all Soviet cosmonauts. It would be very nice if *Spaceflight* were to publish it first.

LAURENC SVITOK
Slovak Republic

Space Anime Admired

Sir, Having just read the article by John Gosling in the February edition of *Spaceflight* (p.41) I feel that I have to congratulate you on it. Being interested in space flight in all its many forms and a fan of Manga films I am pleased that you have brought attention to some of the films which people may miss due to anime not being in mainline culture.

JIM LOTT
Bristol, UK

Almaz Military Programme

Sir, I would like to recommend a recently published German booklet on the military version of the Almaz space station [1]. Its author, Dr Przybiski, is one of the leading German experts on Russian cosmonautics and in this booklet you will find a lot of new, till now unknown facts and pictures about the UR-500 (Proton) launch vehicle and the military space station Almaz. Here is an example:

The ferry ship TKS for the Almaz space station consisted of two parts: the orbital compartment FGB (Functional and Cargo Module) and the return capsule VA (Mercury). All flights of the so called FGB (production code 11F77) are listed as shown in the table.

Name	Serial No.	Launch
Cosmos 929 (TKS-1)	161S	17.07.1977
Cosmos 1267 (TKS-2)	163S	25.04.1981
Cosmos 1443 (TKS-3)	164S	02.03.1983
Cosmos 1686 (TKS-4)	165S	27.09.1985
Kvant 1 (manoeuvring module)	166S	30.03.1987
Polyuz (Skif-DM)	162S	15.05.1987

A similar FGB module is now to be used as a manoeuvring unit for the International Space Station Alpha.

The booklet gives a lot of answers to many unsolved questions like test flights of the VA capsule, the configuration of the whole Kvant-1 system including the manoeuvring unit, the origin and history of the UR-500 (Proton) launch vehicle and so on.

STEFAN WOTZLAW
Dessau, Germany



A VA capsule (11F74) photographed in the large Proton assembly hall at the Khrunichev enterprise in Moscow. It was a left-over of the Almaz programme and was said to have been twice in orbit with cosmonaut dummies on board. A significant feature of the capsule was its reusable heat shield which showed no signs of damage from the two missions.

Reference

1. O. Przybiski, *Almaz - das supergeheime militärische Orbitalstationsprogramm der UdSSR*, (The Super Secret Military Space Station Programme Almaz, Deutsche Raumfahrttausstellung Morgenröthe-Rautenkrantz e.V. Am Kirchberg 3, 08262 Morgenröthe-Rautenkrantz, Germany.

Coca-Cola in Space

Sir, In Spacehab-3 on STS-63, Coca-Cola flew an unusual "experiment" - an honest-to-goodness coke dispenser (FGBA designation).

The photo shows the flight hardware with Dr Ashis Gupta of Coke, who developed it.

JOEL W. POWELL
Space Information Canada
Alberta, Canada



COCA-COLA

Apollo 13 Movie

Sir, Following the article "Have Rocket will Travel, Cinematic Visions of the Dawn of the Space Age" (*Spaceflight*, February 1995, p.44), I would like to tell you about my visit to the Kennedy Space Center in April 1994 to see my second space shuttle launch (after STS-45 in 1992), namely STS-59 Endeavour with my friends Tom Jones and Linda Godwin on board.

I was waiting for the crew walk-out when a friend who was with me said, "Look to your right, the two people just near you wearing caps are Tom Hanks

and Ron Howard". It was incredible! I spoke for some minutes with them and so I learned about the making of the movie *Apollo 13* with Tom Hanks in the role of Lovell. Hanks and Howard were very nice. But our meeting was stopped by the arrival of the STS-59 crew going to the launch pad and so I had no time to take pictures of them. But it was a very nice memory for me and my friend.

PIERRE-EMMANUEL PAULIS
Belgium

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

SATELLITE DIGEST-275

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
INTELSAT 704	1995-001A	Jan 10.26	ER	Atlas 2AS	3,661	Jan 16.87	0.01	1,436.87	35,794	35,810	[1]
EXPRESS 1	?	Jan 15.57	Uchinoura	M-3S-2	765	Jan 15.6	31	88.09	110	250	[2]
Tsukada 1	1995-002A	Jan 24.16	Plesetsk	Cosmos	825 ?	Jan 25.71	82.97	104.97	965	1,021	[3]
Astrid	1995-002B				28	Jan 25.71	82.93	105.02	965	1,026	[4]
FAISAT	1995-002C				114	Jan 26.85	82.93	104.99	968	1,021	[5]
ApStar 2	None	Jan 25.94	Xi	Chang CZ-2E	3,000 ?	Failed to reach orbit					[6]
UFO 4	1995-003A	Jan 29.06	ER	Atlas 2	2,800 ?	Feb 2.81	5.39	1,171.36	24,474	36,388	[7]

NOTES

- Communications satellite, mass of which quoted above is at launch: the dry mass of the satellite is approximately 1,500 kg. To be located over 66 °E.
- EXPRESS ("EXPeriment REuseable Space System") is a joint Japanese-German programme (ISAS in Japan), using a re-entry vehicle supplied by Khrunichev in Moscow and based upon one of their Salyut re-entry capsules (possibly also related to the 1960s-1970s FOBS re-entry vehicles). Carried six experiments (total mass 153 kg): three from Germany and three from Japan. A launch vehicle second stage attitude control problem prevented the planned orbit (31.07 °, 210-398 km) from being attained and the spacecraft and kick motor reached a low orbit from which they quickly decayed. It had been planned to recover the re-entry module in Woomera, Australia after 5.5 days in orbit.
NOTE: USSPACECOM has not issued any catalogue numbers or international designations for this launch (it should be catalogued as 1995-002) because it is claimed (probably incorrectly) that none of the sensors used by USSPACECOM tracked the launch. As a result of this bureaucratic decision by USSPACECOM the counting of the remaining launches for 1995 is currently in error by one. The orbit listed above is an approximate one, quoted by the Japanese.
- Civilian navigation satellite in the "Tsikada" system: previous launches have been within the Cosmos programme, apart from a few satellites starting in 1969 which carried international search-and-rescue transponders which were named Nadezhda: Tsikada 1 is co-planar with Cosmos 2123.
- Astrid is a magnetospheric research microsatellite, launched for the Swedish Space Corporation. Satellite carries a neutral particle imager, a miniature UV imaging system and an electron spectrometer.
- FAISAT is a store-and-forward communications satellite, modified by and launched for Final Analysis Inc in Greenbelt, Maryland.
- ApStar 2 was launched for APT Satellite Co Ltd: planned for deployment over 76.5 °E. The satellite apparently exploded 51 seconds after launch, violently enough to destroy the launch vehicle: six people were killed and 23 were injured by debris from the explosion. It was later reported that the explosion of ApStar 2 was due to a propellant leak.
- "UHF Follow-On" satellite, also called USA 108. Mass of satellite on station is 1,360 kg. First UFO satellite to carry the EHF ("extremely high frequency") communications payload, to be carried on all future UFO satellites. To be located over 183 °E.

ADDITIONS AND UPDATES

- 1977-048A GOES 2 was boosted off-station over 224 °E during 1995 January 19-28.
- 1984-023A INTELSAT 508 was boosted off-station over 179-180 °E approximately 1994 December 17-18: it was still drifting at the end of January 1995.
- 1985-004A Molniya-3 23 decayed from orbit 1994 December 5.
- 1985-076C ASC 1 drifted off station over 232 °E during October 1994: it is unclear whether or not the satellite is still operating.

- 1985-087A The name of this satellite is INTELSAT 512, not INTELSAT 501 as quoted in the up-dates in the last issue of "Satellite Digest".
- 1987-022A GOES 7 was boosted off-station over 246-247 °E during 1994 December 20-30: it was still drifting at the end of January 1995.
- 1988-066A Cosmos 1961 drifted off-station in summer 1993 and is no longer operational.
- 1989-004A Gorizont 17 was boosted off-station over 133-134 °E approximately 1995 January 17: this satellite has been leased to the RIMSAT Corporation.
- 1994-053A Cosmos 2290 has continued to manoeuvre in orbit: 1995 January 27.28, 64.80°, 89.88 minutes, 193 km, 344 km 1995 January 31.50, 64.80°, 90.21 minutes, 180 km, 390 km.
- 1994-055A The initial mass of Optus-B 3 should be "3,000 ?" kg.
- 1994-067A Ekspress 1 was boosted off-station over 70 °E during 1995 January 4-5.
- 1994-079A Add the following geosynchronous orbit for Orion 1: 1995 January 7.90, 0.06°, 1,436.16 minutes, 35,775 km, 35,801 km. The satellite is deployed over 321-322 °E.
- 1994-087A Add the following orbital data for Raduga 32: 1995 Jan 11.01, 1.45 deg, 1,436.17 minutes, 35,784 km, 35,792 km The orbit has the satellite located over 70 deg E. Comment Regarding "Foton 6". Comments have been made concerning the naming of launch 1994-033 - whether the payload should be named "Foton 6" which was used in an earlier issue of "Satellite Digest" or "Foton 9". The following discussion is extracted from "Worldwide Satellite Launches" published on July 14th 1994, the publication from which "Satellite Digest" is derived: "Ninth Foton microgravity research/materials processing satellite to be launched. The first three flights were within the Cosmos programme, and the previously named Foton missions have been identified as Fotons 1-5: however, the launch announcement identified the new launch as "Foton 9" rather than the correct sequential "Foton 6" used here."
- With so many former Soviet programmes now appearing outside the Cosmos programme after being hidden within it for so long there is the problem of naming these payloads. Do we start the count 1, 2, 3 from the first flight within the Cosmos programme or do we begin with "4" when the non-Cosmos name is announced? The tendency has been to take the latter course, and in the case of Foton the Russians themselves have done this. For numerical consistency "Foton 6" was taken for the 1994 launch, although the launch announcement named the satellite "Foton 9": using the latter number would have resulted in an apparent gap in the launches with no flights of Fotons 6, 7 or 8 being identified. To date, only the Foton programme has created this problem - with other programmes like Nadezhda, Luch, GEO-1K and now Tsikada the launch announcements simply do not issue sequential numbers to the satellites.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

5 April 1995

7 - 8.30 pm

Alternative Space Launch Concepts

Colin Jack

Oxford Mathematical Designs

Launching orbital payloads by rocket costs upwards of £4,000/kg. Colin Jack will be discussing cheaper proposals, and trying to pick some winners. Suggestions from the floor, please!

3 May 1995

7 - 8.30 pm

The Design, Instrumentation and Function of the Cassini Mission Titan Surface Probe (Huygens Lander)

Dr John Zarnecki

University of Kent

The mission will be described with emphasis on ESA's contribution, the Huygens Probe, which will land on the surface of Saturn's largest moon Titan.

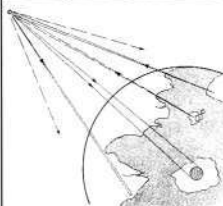
12 August 1995

50th Annual General Meeting

The 50th Annual General Meeting of the Society will be held at The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1, on **Saturday, 12 August 1995 at 12 noon.**

Admission is by ticket, available to Corporate Members (i.e. Fellows of the Society) only, who should apply in good time enclosing a stamped addressed envelope.

Council nomination forms are obtainable from the Executive Secretary. These must be completed and returned not later than 12 noon on Friday, 19 May 1995. If the number of nominations exceeds the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all Corporate Members.



AN EVENING TO HONOUR ARTHUR C. CLARKE

Scientific Societies Lecture Theatre,
Fortress House,
New Burlington Place, London W1

at 6.30 pm on 18 August 1995

The Society will present its Space Achievement Medal to Arthur C. Clarke, in honour of his work, together with a special commemorative plaque to mark the 50th Anniversary of the concept of geostationary satellites advanced by Arthur in 1945.

The evening will include a guest speaker who will discuss the historic events which followed publication of the original concept and conclude with a buffet reception.

Tickets are available to Members at £20 per person. Early application should be made to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

7 June 1995

7 - 8.30 pm

Magellan Looks at Venus

Prof Dan McKenzie

Department of Earth Sciences,

University of Cambridge

For four years Magellan mapped the whole Venus surface with a resolution of about 100 m. We now have better maps of its surface features and gravity than we do of Earth.

Spectacular images of the surface show how different Venus is from Earth. Though the origin of many of the features is not yet properly understood, the gravity field has already provided some clues. Unlike Earth, the topography of Venus is dominated by mantle up- and downwelling. Perhaps the most important result of the whole mission is that it has shown us that we still have a great deal more to learn before we understand what controls the dynamics of rocky planets.

10 July 1995

7 - 8.30 pm

Australia in Space

J. Heyman

Western Australia

The lecture will commence with a discussion of Australia's early space history, including the development of Woomera, the sounding rocket programmes conducted at Woomera, the involvement with the British and ELDO space programmes, the cooperation with the US and the launch of Australia's own Wresat satellite.

The lecture will then discuss the limited activities from Wresat until the 90s and will finally have a look at the recent five year space plan promulgated by the Australian Space Council.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

26 April 1995

10 - 4.30 pm

Electronics in Space

Major advances in electronics in recent years have had an enormous impact on spacecraft design and on what can be accomplished in space within a given mass and volume.

This one-day symposium will cover the latest information concerning the effects of the space environment on advanced electronics systems.

3 June 1995

10 - 4.30 pm

Soviet/CIS Astronautics

The Soviet/CIS symposium is acknowledged as one of the foremost meetings for the presentation of material on current and historical reviews of the space programmes of the Soviet Union and its successor Republics.

13 September 1995

10 - 4.30 pm

Low-Cost Satellites

In response to a general concern about the escalating expense of space missions, many organisations have been attempting to reduce costs substantially, primarily by the innovative design of micro- and mini-satellites. Some of the topics relevant to this theme will be presented.

JBIS



The April 1995 issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

Science Systems in Space (Part II)

Automated Commanding for Eumetsat

SCOS-II Development

Advances at the UK Earth Observation Data Centre

The Radarsat Satellite Simulator: Advances in Satellite Simulation

The Ulysses Flight Dynamics Software System

The Oratos Support Layer

Copies of JBIS, priced at £5.00 (US\$9.00) to members, £17.50 (US\$32.00) to non-members, post included, can be obtained from the address below. Back issues are also available.

The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ England.

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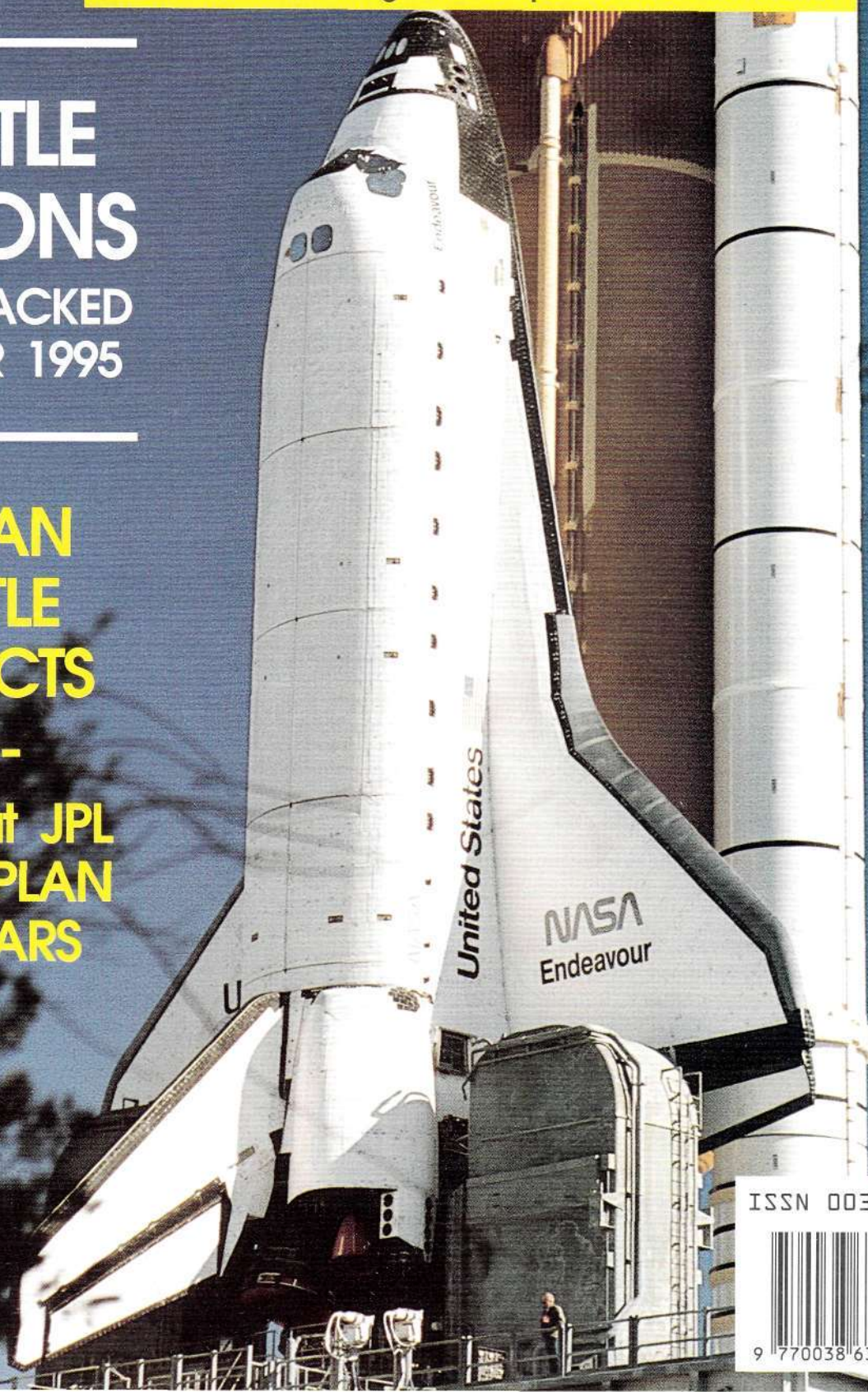
SHUTTLE MISSIONS

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RUSSIAN SHUTTLE PROJECTS

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STS-59: Mission Highlights

Launch Date: 9 April 1994

Perhaps the most challenging part of this shuttle mission was experiment SRL1, the first flight of the Space Radar Laboratory. To study the surface of the Earth with this instrument package Endeavour was required to make more than 400 separate position manoeuvres to achieve the ground track and orbiter alignment essential for radar mapping the surface and geology of the Earth. Other important tasks included tests of a new form of video-microscope capable of studying biological processes, such as cell growth and movement, under zero-G conditions. Pollution studies included mapping the global and local distributions of CO important in the study of ecology and the ecosphere. There are a number of spectacular SRL1 Earth views. 59 mins

STS-60: Mission Highlights

Launch Date: 3 February 1994

This Discovery mission included Russian cosmonaut Sergei Krikalev and marked the start of a new era of USA and Russian Cooperation in Space. The mission carried the Spacehab module and a three-dimensional gravitational accelerometer. Other experiments included the study of crystal growth under zero-G, the deployment of BREMSAT and the launch of six Orbital Debris Radar Calibration Spheres (ODERACS), ranging from 5 to 15.2 cm in diameter. 58 mins

STS-64: Mission Highlights

Launch Date: 9 September 1994

The 19th flight of Discovery conducted a diverse range of experiments concerned with Earth environment monitoring technology. The mission included the release and recovery of the 2800 pound SPARTAN satellite. The mission included extended EVA activities. Nitrogen propellant recharging of the astronauts' manoeuvring unit, the SAFER (Simplified Aid for EVA Rescue), is shown. Its manoeuvring ability and its attitude control system are impressively demonstrated. The mission also included a series of atmosphere monitoring experiments with the Lidar in Space Technology Experiment (LITE) instrument. 1 hr 4 mins

STS-65: Mission Highlights

Launch Date: 8 July 1994

STS-65 was the 17th trip into space made by space shuttle Columbia which spent 14 days in orbit. The mission conducted a wide range of experiments concerned with biochemical, biological and human physiological processes in reduced to zero-gravity environments. The science crew included for the first time a Japanese woman as a mission specialist. The second International Microgravity Laboratory (IML2) science programme was made up of a number of experiments ranging from protein separation and electrophoresis, to the study of growth and breeding of fruit-flies in zero to 1G variable-gravity environments. The effects of zero-G on the swimming orientation of goldfish, and the behaviour of adult Japanese Red Bellied newts and the growth of their embryos were among a range of aquatic experiments performed in a special unit called the AAU (Aquatic Animal Experimental Unit) which was probably the first equivalent of an aquarium in space. The video includes some excellent views of Earth. There is only a limited sound commentary. 57 mins

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The May 1995 issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

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The Society has acquired a stock of the RAE Table of Earth Satellites, a substantial volume originally published at £95 which it is now making available to members at the incredible price of £7.50 (US\$15), plus £4.50 postage and packing in the UK. £9 (US\$16) abroad.

The RAE specialised in the analysis of satellite orbits to determine the Earth's upper atmosphere density and winds, as well as its gravitational field. In order to choose suitable satellites, a listing was necessary, thus leading, over the years, to the present volume containing data on more than 17,000 satellites, including fragments, in 893 pages of tabulation. Extensive revisions have been made to this, the fourth edition, to include not only all new launchings to extend the period covered to 1989 but also to incorporate over 1,000 revisions to the earlier data.

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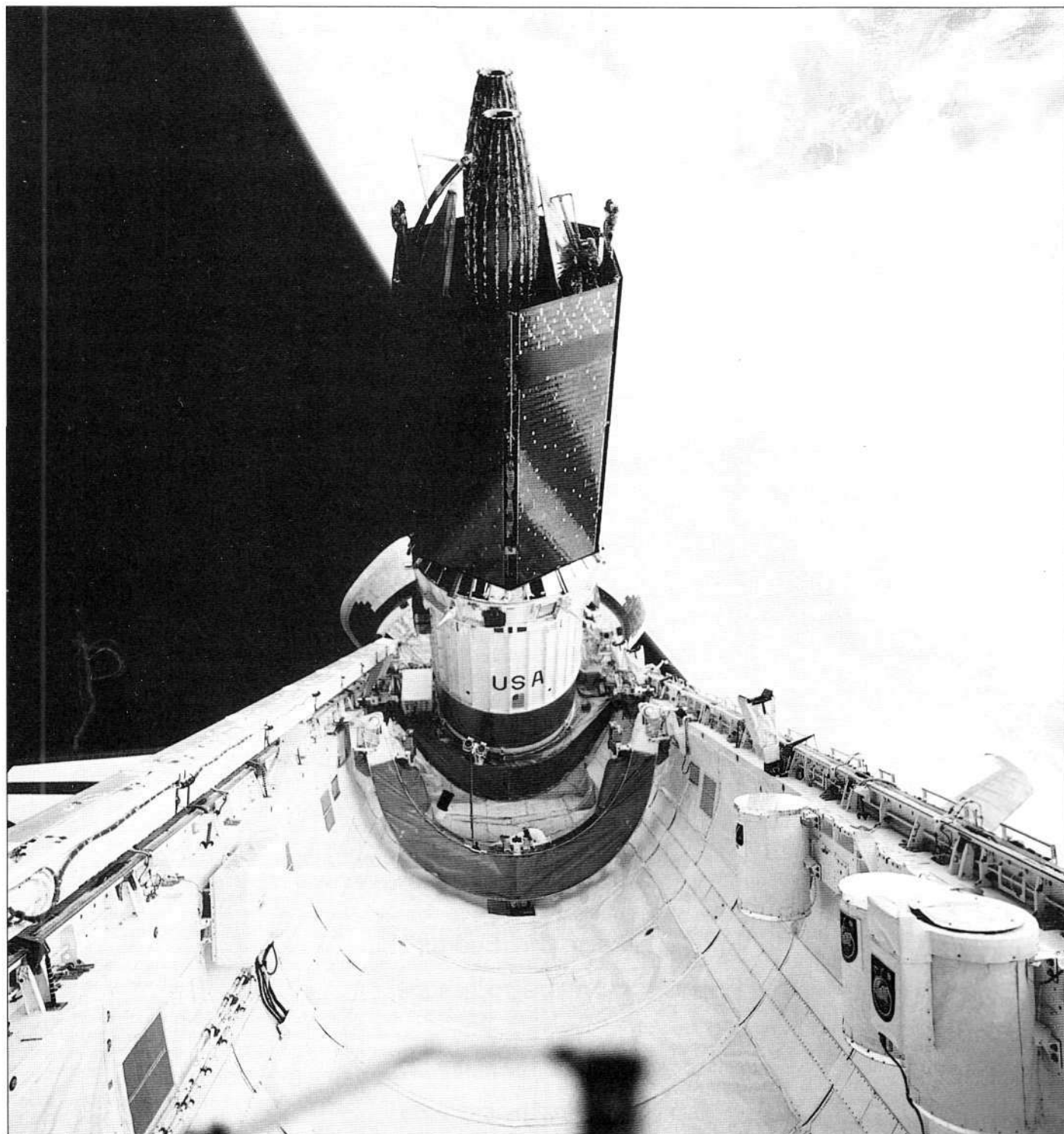
Space Miscellany

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Front Cover: A spectacular shot of the Space Shuttle Endeavour as it inches its way on its support and transport hardware to Launch Pad 39A from the Vehicle Assembly Building on 8 February 1995 for mission STS-67. Once at the pad, the Shuttle and launch platform are deposited atop support columns in preparation for launch.

The fully assembled Space Shuttle Endeavour weighs 2 million kg (without payloads); and the mobile launch platform on which it was assembled and from which it lifts off weighs 4.19 million kg. The crawler-transporter which carries the platform and Shuttle weighs 2.7 million kg.

NASA



Tracking and Data Relay Satellite (TDRS-E) leaves the payload bay of the Earth-orbiting Atlantis (STS-43) on 2 August 1991 a mere six hours after the Space Shuttle was launched from Pad 39A at Kennedy Space Center, Florida. TDRS was placed in a geosynchronous orbit and after on-orbit testing was designated TDRS-5. The communications satellite replaced TDRS-3 at 174° West longitude. The backbone of NASA's space-to-ground communications, the Tracking and Data Relay Satellites have increased NASA's ability to send and receive data to and from spacecraft in low-earth orbit to more than 85% of the time.

NASA

New TDRS Spacecraft

Hughes Space and Communications has won a \$481.6 million contract to build NASA's next generation of Tracking and Data Relay Satellites (TDRS) which are to operate for 11 years. Hughes will build three satellites, the first of which will be delivered in four years time.

The TDRS satellites enable NASA to communicate with the Space Shuttle, the future space station and

unmanned spacecraft in low Earth orbit. While the new satellites will be compatible with NASA's existing equipment, which operates in the Ku and S bands, they will add Ka-band capability. The satellites, designated TDRS H, I and J, are medium-power versions of the proven HS 601 spacecraft design and will have two 15-foot-diameter single-access antennas, using Hughes' patented Springback design. Each will

be able to simultaneously transmit and receive, enabling the spacecraft to carry on two independent two-way communications functions. In addition, there will be an S-band phased array antenna that can receive signals from five spacecraft simultaneously, and another S-band antenna for transmission. The necessary 2,040 watts of power will be provided by two wings covered with silicon solar cells. ■

"Switchboard in the Sky"

Shuttle to Deploy Sixth Tracking and Data Relay Satellite (TDRS)

The orbiter *Discovery's* next major payload, targeted for deployment during the eight-day STS-70 mission in late June 1995, has become so familiar to the Space Shuttle programme in recent years that it tends to be regarded almost as a minor objective. Nevertheless, although the Tracking and Data Relay Satellite (TDRS) has seen five successful deployments over the past 12 years, it is still described as one of the Shuttle's most demanding tasks and is of crucial importance to countless US manned and unmanned scientific spacecraft operating from low-Earth orbit.

Launch and Deployment

Discovery is scheduled to lift-off from Pad 39B at the Kennedy Space Center (KSC) in Florida at 10:16 am Central Standard Time (CST) on 22 June 1995 at the opening of a three hour and 58 minute 'window' for that day. Shortly after insertion into a 297 km orbit, inclined at 28.45 degrees relative to the equator, the payload bay doors will be opened and the STS-70 astronauts will work towards a first deployment opportunity for their TDRS payload (designated TDRS-G) some six hours and 13 minutes into the mission.

The payload starts its journey folded in its 'stowed' configuration with all solar panels and antennae wrapped around the central bus and mounted atop a two-stage Boeing-built Inertial Upper Stage (IUS) solid-propellant booster unit, which will later carry the satellite into geostationary orbit. The two components are secured to the Shuttle payload bay by means of a doughnut-like cradle, which acts as a 'tilt-table' to raise the TDRS-G/IUS stack firstly to 29 degrees for command and communications checks,

About the Crew

Discovery's Commander is USAF Colonel Terence T. 'Tom' Henricks, who will be undertaking his third spaceflight. He was born on 5 July 1952. An astronaut since June 1985, Henricks has previously flown as Pilot of STS-44 in November 1991 and as Pilot of STS-55 in April 1993, amassing more than 405 hours in space.

Pilot Kevin R. Kregel is making his first flight on the Shuttle having joined the astronaut corps in March 1992. He was born on 16 September 1956.

The three Mission Specialists are Dr Mary Ellen Weber, US Army Major Nancy Jane Sherlock and Dr Donald A. Thomas.

Weber has not flown into space before and, like Kregel, she joined the astronaut corps in March 1992. She was born on 24 August 1962.

Sherlock is flying her second Shuttle mission and has been an astronaut since January 1990 and Mission Specialist on STS-57 in June 1993. Her space experience amounts to 239 hours. She was born on 29 December 1958.

Thomas is also making his second Shuttle flight, having served as a Mission Specialist on STS-65 in July 1994. He was born on 6 May 1955. He joined NASA as an astronaut in January 1990 and has spent 353 hours in space.



At the end of mission STS-63, *Discovery* glides in for a dawn landing on the brightly-lit Runway 15 of the KSC Shuttle Landing Facility. About 2 hours 40 minutes later *Discovery* was towed to the Orbiter Processing Facility for post-flight deservicing and preparation for mission STS-70. On its return from mission STS-70, *Discovery* goes to California for a refit before its next mission in early 1997. (For details of mission STS-63 see p. 150.)

NASA

BY BEN EVANS

West Midlands, UK

and finally to the deployment angle of 58 degrees relative to the payload bay.

When angled correctly, on their fifth orbit of the Earth, *Discovery's* crew will release the stack by activating a number of spring mechanisms arranged around the rim of the tilt-table. Commander Henricks will then use the Shuttle's thrusters to manoeuvre to a safe distance before the IUS first-stage motor ignites approximately one hour after deployment.

The first burn will place the TDRS-G/IUS combination into an inertial transfer orbit, before the second-stage motor fires approximately six hours and 17 minutes after deployment to boost the payload into geostationary

orbit. The IUS second-stage will then separate from TDRS-G, which will unfurl its antenna and other appendages, while drifting into its assigned orbital position at 79 degrees West longitude using its own attitude-control thrusters.

TDRS Payload Details

When it reaches its final operational slot in geostationary orbit some 35,680 km above the Earth, TDRS-G will resemble a giant windmill in physical appearance, since it contains four 'paddles', attached to beryllium booms, which extend from a hexagonal satellite bus. Two of these paddles are flat, square solar panels measuring 3.8 m along each side, while the other two are umbrella-shaped Ku/S-band parabolic antennae, each with a diameter of 4.9 m.

In total, the satellite will weigh 2,540

TDRS Spacecraft Launch and Operational Status.

Spacecraft	Mission	Functional Status	Longitude
TDRS-1	STS-6 Apr 5, 1983	Partial	85°E
TDRS-2	STS-51L Jan 1986		
TDRS-3	STS-26 Sept 29, 1988	Partial	171°W
TDRS-4	STS-29 Mar 13, 1989	Full	41°W
TDRS-5	STS-43 Aug 2, 1991	Full	174°W
TDRS-6	STS-54 Jan 13, 1993	Full	62°W

kg when operational and measure 17.4 m between the tips of its two parabolic antennae.

TDRS-G will neither alter nor process communications; instead, it is a 'repeater' and its role has been likened to a 'switchboard in the sky'. Its uplink channels receive transmissions from ground stations, amplify them and retransmit them on a different frequency to another manned or unmanned spacecraft. By contrast, its downlink channels receive transmissions from another manned or unmanned spacecraft, amplify them and retransmit them to Earth. As a result, the TDRS principle is often nicknamed the 'bent-pipe' mode, since communications pass through the sat-

ellite in much the same manner as fluids flowing through an L-shaped or V-shaped pipe.

All communications between TDRS-G and the Earth will be conducted through a two metre diameter Ku-band dish antenna, located close to the hexagonal satellite bus. Transmissions from the Earth targeted at other spacecraft will pass through one of TDRS-G's two giant parabolic antennae or through an array of 30 cylindrical S-band antenna elements located on top of the central bus.

The two parabolic antennae are known as 'single-access antennae' because they are only capable of handling one spacecraft's communications traffic at any one time. However, they

are steerable and can be turned to precisely face a target spacecraft, which increases their reception and transmission rates to 300 megabits per second. The 30 antenna elements are called 'multiple-access antennae' since they can handle the traffic of up to 20 spacecraft simultaneously. Unlike the single-access antennae, they are not steerable and therefore their reception and transmission rates are much slower, amounting to 50 kilobits per second.

The TDRS-G central bus is composed of three main modules. The Equipment Module (EM), also known as the 'Spacecraft Module', is located in the lower area of the bus, and carries station-keeping and attitude-con-

STS-70: Secondary Payload Experiments

In addition to the Mars-96 Sensor Test, 12 other experiments will be accommodated in Discovery's crew compartment, of which seven are dedicated to life science and biomedical research.

Life Science and Biomedical Research

These experiments are the Physiological & Anatomical Rodent Experiment (PARE), Commercial Protein Crystal Growth (CPCG), Space Tissue Loss (STL), Biological Research in Canisters (BRIC), the Visual Function Tester (VFT), Microcapsules in Space (MIS) and the Bioreactor Demonstration System (BDS).

PARE, sponsored by the National Institute of Health's Rodents division, will involve monitoring the physiological and anatomical changes taking place in the bodies of several white rats when exposed to the effects of microgravity. The rodents will be accommodated in an animal enclosure facility located inside a standard middeck locker.

The CPCG apparatus, which is one of the

most-flown Shuttle secondary experiments, will once again be growing high-quality crystals of numerous key proteins as part of an ongoing pharmaceutical research programme. It is hoped that by conducting a close molecular analysis of the crystals after the flight using a variety of techniques - including X-ray diffraction and computer modelling - it will be possible to develop improved pharmaceutical products to help combat life-threatening diseases.

STL, sponsored by the National Institute of Health's Cells division and alternatively designated NIH-C, is an experiment to examine muscle and bone cell biomedical and functional changes in the microgravity environment. Specifically, studies will be conducted into skeletal and cardiac muscle atrophy, and several candidate pharmaceutical products will be evaluated for their efficacy.

The BRIC investigation, which has already flown three times - on STS-64, STS-68 and most recently aboard the Spacehab module on STS-63 - will study the effects of microgravity on numerous tiny life science specimens held in a Plant Canister and gaseous nitrogen freezer. Previous experiments with BRIC have included gypsy moth eggs, flown to determine their ability to produce sterile moths when exposed to the space environment.

The hand-held VFT device, resembling an elongated pair of binoculars in appearance, is a biomedical science study to determine the effects of microgravity on human visual performance. The STS-70 astronauts will use a device provided by the Department of Defense (DoD) to determine any changes in their perception of contrast, direction or patterns in space.

The MIS experiment is designed to evaluate the effects of microgravity on methods used to encapsulate drugs within biodegradable polymer containers and, in doing so, will combine the materials science and biomedical science disciplines to produce a pharmaceutical product in space.

The BDS payload, developed by the Life Sciences Division at NASA's Johnson Space Center (JSC) of Houston, Texas, was previously flown on STS-62 and will be used to determine a threshold mass for the

transfer/diffusion of glucose and oxygen into a static cell under microgravity conditions. Attempts will be made to grow 'three-dimensional' human cells in microgravity, including cancer cells, as part of evaluations of a prototype space bioreactor.

Other Experiments

The remaining five experiments located within Discovery's crew cabin are known as the Shuttle Amateur Radio Experiment (SAREX), the Hand-held Earth-oriented Real-time Co-operative User-friendly Location-tracking and Environmental System (HERCULES), the Window Experiment (WINDEX), the Radiation Monitoring Experiment (RME) and the Air Force Maui Optical Site (AMOS).

SAREX, provided by NASA's Office of Space Communications, has also become a regular feature aboard Shuttle missions and consists of a low-cost apparatus providing space-to-ground radio and slow-scan television communications for amateur radio operators.

HERCULES, which boasts one of the longest and most impressive acronyms in the history of manned space flight, was developed by the Naval Research Laboratory (NRL) and consists of a Nikon camera together with a gyroscopic Inertial Measurement Unit (IMU) to precisely determine the latitude and longitude of Earth surface features photographed. Capable of pinpointing sites down to a single nautical mile, it is intended as an upgraded version of the Latitude/Longitude Locator (L3) which had an accuracy of some ten nautical miles.

WINDEX, which previously flew aboard the Spacehab module on STS-63, is a DoD experiment designed to obtain calibrated measurements of optical emissions from the Shuttle during its flight. The RME instrument, also provided by the DoD, is located in a middeck locker, and is designed to measure gamma-ray levels in the crew cabin.

The AMOS investigation is a non-complex payload, requiring no on-board hardware or significant crew participation. It involves firing the orbiter's thrusters when it flies over the Hawaiian island of Maui, from where US Air Force electro-optical sensors will observe the plume phenomenon. The experiment will also serve to calibrate the ground-based sensors and evaluate their ability to measure rocket plumes in space.

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tol subsystems. It also contains equipment for the storage and management of the TDRS power supply and also for telemetry and tracking operations. The Communications Module (CM) is the upper area of the bus and contains the electronic equipment for regulating the flow of transmissions between the various antennae. The third module is the Antenna Module (AM), which is a platform on top of the bus accommodating the 30 cylindrical antenna elements.

TDRS-G was built by the TRW company in co-operation with NASA's Goddard Space Flight Center and the US Air Force Space Command. Although it is designated as the seventh mission in the series, it will actually become the sixth spacecraft to be placed into orbit, following the loss of TDRS-B aboard Challenger in January 1986.

Mars-96 Sensor Test

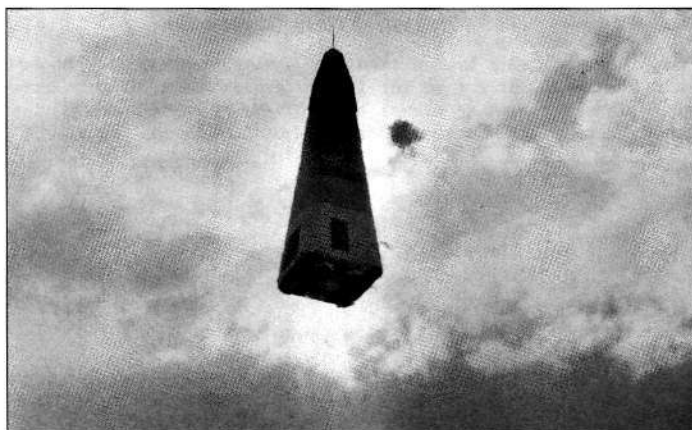
With the deployment of TDRS-G successfully completed, the STS-70 astronauts will settle down to a host of other secondary objectives during the remainder of their flight. Also in the payload bay alongside TDRS-G will be an experiment called the Inter-Mars Tissue Equivalent Proportional Counter (ITEPC), which previously flew aboard STS-65 in July 1994.

The ITEPC assembly, attached to an Adaptive Payload Carrier unit, is designed to evaluate a radiation-monitoring instrument which will be part of NASA's contribution to the joint Russian/International Mars-96 mission, postponed from November 1994 due to funding difficulties. Experiment investigators are testing the instrument's ability to withstand the harsh radiation encountered during the lengthy cruise to Mars in addition to providing information about levels of radiation absorbed by astronauts during spacewalks.

KSC Landing

Assuming an on-time launch, Discovery is scheduled to touchdown on KSC's Shuttle Landing Facility (SLF) runway on 30 June 1995, after a mission elapsed time of eight days. STS-70 will be Discovery's last flight before the orbiter is transported back to prime contractor Rockwell International's Palmdale facility in California for a protracted period of modification and refurbishment. This includes the installation of the new Multifunction Electronic Display System (MEDS) 'glass cockpit' computer displays and subsystems to replace the Shuttle's outdated flight deck instruments. Discovery's next flight, STS-82, is not expected to take place before February 1997.

In the meantime, the main legacy left by the STS-70 mission - the sixth of NASA's switchboards in the sky - will continue to benefit the programme for many more years to come. ■



The DC-X in flight in September 1993.

McDONNELL DOUGLAS

DC-X Tests to Resume

NASA Requests Proposals for SSTO Test-Bed

One step backward for every two steps forward, that seems to be the way that the SSTO programme is developing. After completing three flights in August and September 1993, the programme was shut down due to lack of funding. There were serious concerns that the programme might be zeroed out entirely in lieu of NASA SSTO efforts.

Finally, on 3 May 1994, just before McDonnell Douglas would have been forced to disband the DC-X flight team, BMDO received \$3.5 million from ARPA to restart tests. Reconditioning the DC-X took until 11 June 1994, when the engines were test fired.

On 20 June, the DC-X lifted off the stand again. Following a more complex path than the three earlier flights, it ascended to 2,600 feet, travelled laterally 1,050 feet, reversed its direction and translated back towards the launch pad, climbing meanwhile to 2,850 feet, and then descended vertically, touching down after 2 minutes, 16 seconds. In a step forward over earlier flights, during which the rocket remained vertical throughout the flight, the angle of attack was varied from 0 to 70 degrees from vertical. This is in preparation for the rotation manoeuvre from nose-first to hover which must take place during an actual SSTO return from orbit, and which the DC-X is intended to demonstrate.

On 27 June 1994, disaster struck. Seventeen seconds into the second flight after refurbishment, hydrogen, which is routinely vented from the tanks before launch, was ignited by air-purge duct fans, ironically intended to disperse the vapours and keep them from accumulating under the craft. The resulting explosion tore a 4 by 15 foot hole in the aeroshell and slightly cracked the liquid hydrogen tank. Surprisingly, even though the explosion occurred during liftoff, the DC-X took off normally and began its preprogrammed flight. Seventeen seconds into the flight, the ground crew noticed pieces of shell falling off and activated the craft's emergency "autoland" procedure. According to Lt. Col. Jess Sponable, Single Stage Rocket Technology program manager for the Ballistic Missile Defense Organization, "This anomaly resulted in successful demonstrations of several important firsts:

executing the autoland sequence and demonstrating an 'aircraft-like abort' mode; landing on the gypsum [instead of the concrete landing pad]; demonstrating the ability to land future SSTO vehicles virtually anywhere; and demonstrating the system's toughness and robustness, since the DC-X continued to fly despite the aeroshell damage."

The DC-X was subsequently returned to Huntington Beach for repairs and a new aeroshell has been fabricated by Scaled Composites of Mojave, Ca. Flight tests will resume in May with a planned ascent to 4,350 feet, picking up where the test series was interrupted by the explosion. Subsequent tests will explore the atmospheric manoeuvring capabilities of the vehicle.

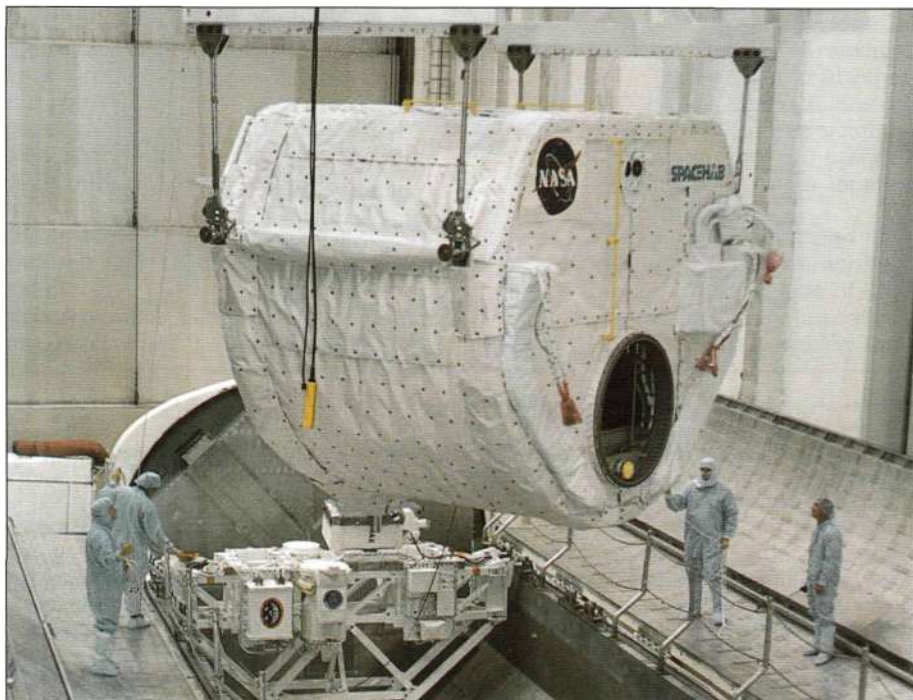
Following completion of the DC-X flight tests, the programme will be transitioned from ARPA management to NASA. McDonnell Douglas will return the vehicle to the factory and upgrade it into the DC-XA. Improvements will include: a new graphite epoxy liquid hydrogen tank, a LOX tank made from a new Russian aluminium-lithium alloy, a new graphite epoxy intertank structure, and a gaseous oxygen-hydrogen reaction control system.

NASA is now the major player in the SSTO game. Recently, NASA released a Cooperative Agreement Notice requesting proposals for the X-33 Reusable Launch Vehicle (RLV) Advanced Technology Demonstrator. The X-33, the formal name for the proposed craft that SSTO advocates were previously calling the SX-2, will demonstrate critical elements of a future Single-Stage-To-Orbit (SSTO) rocket-powered RLV (Reusable Launch Vehicle). The X-33 will be an integrated systems test-bed for advanced launch technologies applicable to a next generation RLV. Three major teams share expressed intentions to respond. McDonnell Douglas and Boeing are teaming up; their proposal will probably be a variation on the Delta Clipper, a full-scale Vertical Take-off, Vertical Landing (VTVL) craft following the DC-X design. Lockheed is also entering the race with a Vertical-Takeoff, Horizontal Landing (VTHL) lifting body featuring a linear aerospike engine. Finally, Rockwell is proposing a winged cylindrical VTHL craft derived from Shuttle technology.

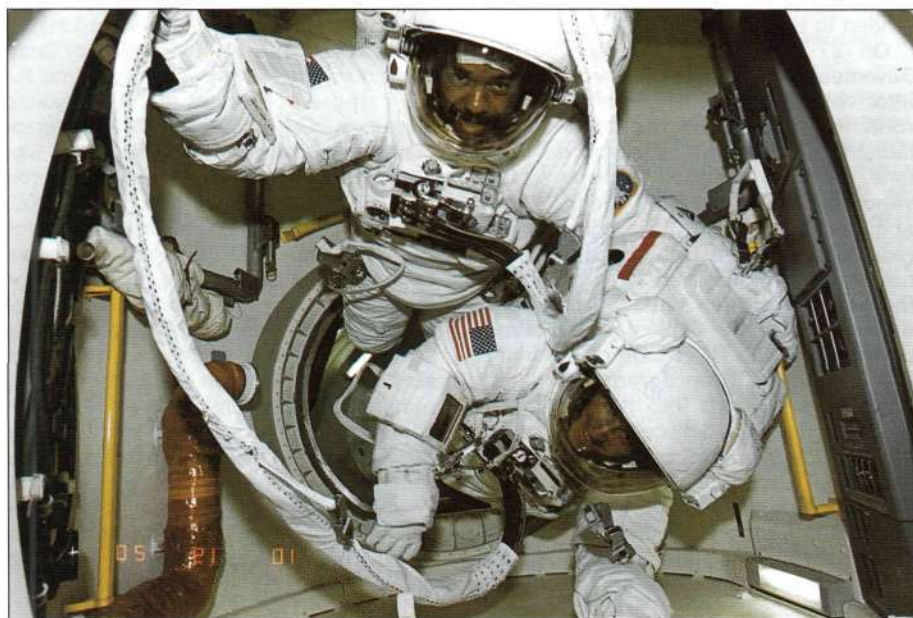
PAUL BLASE

Payload Preparation

Cargo bay payloads are being loaded into the payload canister for transfer from the Operations and Checkout Building to the Orbiter Processing Facility in November 1994. Below is the Hitchhiker crossbay carrier holding several experiments and above is the Spacehab-3 module, also containing experiments. Still to come is the SPARTAN-204. NASA



Vladimir Titov in orbit with vials of samples for an experiment in Spacehab-3. NASA



E. Rudolf van Beest at Pad 39B with the countdown underway on 1 February.
E. RUDOLF VAN BEEST

Payload Deployment



The blackness of space and a part of the Earth's horizon form the backdrop for this 70mm frame of the free-flying SPARTAN-204 satellite, which was later re-captured by the crew and used for manoeuvring evaluations by the two spacewalkers. NASA

Departure for EVA

Left: Bernard Harris (top) and Michael Foale ready to egress the airlock for their spacewalk. NASA

DISCOVERY

Orbital Flight:

3 - 11 February 1995



The crew depart from the Operations and Checkout Building and head for Discovery on Launch Pad 39B on 2 February. The liftoff attempt was later scrubbed when one of Discovery's three Inertial Measurement Units failed and had to be replaced. Leading the way are Mission Commander James D. Wetherbee (far right) and Pilot Eileen M. Collins. Behind them are (from left) Payload Commander Dr. Bernard A. Harris Jr. and Mission Specialists Vladimir G. Titov, Janice Voss and C. Michael Foale. NASA

EVAs Follow Mir Rendezvous

Highly Successful Mission After Anniversary Launch

The Space Shuttle Discovery was launched on mission STS-63 on the morning of 3 February 1995 one year to the day after its launch on STS-60 on 3 February 1964. In a further coincidence, STS-60 and STS-63 both carried Spacehab science laboratory modules. The mission had been set to launch on 2 February but a one day delay was required to replace a faulty Inertial Measurement Unit.

Mission Objectives

The primary objective of the mission was a rendezvous with the Mir space station, the exercise being the first element in a combined American-Russian space station programme. STS-63's objective was to test the rendezvous procedures to be used to dock the shuttle to Mir on mission STS-71 in June 1995.

In addition to Spacehab-3, Discovery carried the SPARTAN-204 deployable/recoverable astronomy satellite. Discovery also carried CSE (Cryo Systems Experiment), GLO-2 (Shuttle Glow Experiment), ODERACS-2 (Orbital Debris Radar Calibration Spheres) and an IMAX camera which was mounted on an experiment support structure in the payload bay. Discovery's middeck area contained SSCE (Solid Surface Combustion Experiment) and a number of the Spacehab experiments and samples which had to be installed in the orbiter at the latest possible time. (See *Spaceflight*, January 1995, p.18 for further details of experiments and crew members).

Preparations

Discovery's preparations for STS-63 began when it returned from mission STS-64 which landed at Edwards Air Force Base in California on 20 September 1994.

Discovery returned to the Kennedy

BY ROELOF SCHUILING
at the Kennedy Space Center

Space Center aboard the Boeing modified 747 carrier aircraft on 27 September and was moved into the KSC Orbiter Processing Facility's work bay two where the STS-64 payload and support equipment were removed. Post flight operations involved the removal of the STS-64 mission Space Shuttle Main Engines and their replacement with SSME 2035, 2109 and 2029 in engine positions 1, 2 and 3 respectively. The three Rockwell Rocketdyne Division STS-63 engines had a combined total of over 11,000 seconds of engine firing time prior to STS-63. Engine installation began on 21 November.

While in the Orbiter Processing Facility Discovery also had the forward reaction control system pod removed for refurbishment on 20 October and replaced on 22 November. Also replaced during this period was the number two Auxiliary Power Unit.

On 29 November the STS-63 payload complement was installed into Discovery's payload bay. After connection of cables and cooling lines to the orbiter, the payloads went through a series of interface verification tests. The interface tests confirm that the payload connections are correct and

that the orbiter can supply power, commands and cooling as required and that the payload elements can communicate with the orbiter.

On 5 January 1995 the orbiter was transported to the Vehicle Assembly Building to be mated with the Solid Rocket Boosters and the External Tank. The mating operation was completed on 6 January and the interfaces between the Solid Rocket Boosters/External Tank and the Discovery were tested and verified.

The complete STS-63 Space Shuttle and its mobile launch platform were moved to KSC's Launch complex 39B on 10 January. This was an advance of one day from the previously planned 11 January rollout on account of the indication of a probable leak in the R3A thruster on the right side Orbital Manoeuvring System pod. The problem could be dealt with much easier at the launch pad with its more extensive access and support systems. During the investigation an indication of a leak was found on thruster R3R which was one of the three other thrusters which shared the same manifold with R3A. Both R3A and R3R were removed and replaced.

A simulated launch count was held on 18 and 19 January and this was followed by loading of hypergolic propellants on the 21st and 22nd. The replaced number two Auxiliary Power Unit was tested by firing the unit for seven minutes on the 23rd.

Countdown to a Five-Minute Launch Window

Final preparations were made for beginning the launch countdown on 29 January and the launch countdown for STS-63 began at 4:30 pm on that date. The countdown clock was started at the T-43 hour mark, however the countdown had a series of built-in-holds designed to bring the clock to T-0 within a few minutes of 12:48 am on 2 February. The actual launch time would be finalised at about one and a half hours before that time to allow a final determination of Mir's orbital parameters.

The STS-63 launch countdown aimed towards a launch window of only approximately five minutes. The launch window was a composite of planar and geocentric phase angle windows supporting the Mir rendezvous. The phase window covers one full planar window each day. Planar windows last no longer than five minutes per day and are constrained by External Tank certification limits in ascent performance. Although there may be many Mir rendezvous phase windows on a given day, the five-minute planar window dictates committing to

one phase window before any launch attempt. The phase window supported a Mir rendezvous during mission flight days 3-4.

In order to increase the probability of a successful launch within the shortened launch window several changes were made to the scheduled built-in-holds (BIH). The nominal countdown has a series of BIHs at T-27 hours of 4 hours duration; T-19 hours of 8 hours; T-11 hours adjustable to bring the nominal launch to T-0 at the desired liftoff time (For STS-60, Discovery's previous Spacehab mission this was 20 hours 50 minutes and for STS-63 it was 20 hours 29 minutes); T-6 hours for 1 hour; T-3 hours for 2 hours; T-20 minutes for 10 minutes; and T-9 minutes for 10 minutes. BIHs are used to insure that time-critical countdown milestones are met.

For STS-63 the T-6 hour BIH was lengthened to 2 hours to insure the External Tank loading was on-time. In addition the T-9 minute hold was lengthened from 10 to approximately (depending on final Mir orbital figures) 40 minutes to insure that no late problems (such as ships or aircraft accidentally straying into the launch area) would impact the launch.

Discovery's countdown proceeded as scheduled. As with previous Spacehab missions, a late access was scheduled for installation of time-critical experiments and samples into the Spacehab module. Since the orbiter was now in a vertical position this required lowering technicians down through the middeck and airlock into the module which was located in the forward end of the payload bay. This operation took place during the L-41:30 hour to L-30:30 hour period, after which the hatches to Spacehab-3 were closed for launch. Middeck experiments were later loaded into the

crew cabin from L-21:55 hours to L-13:50. (L-times are calculated from planned launch, T-times are countdown clock time and are affected by BIH lengths).

Shortly after completion of the installation of middeck experiments and as Discovery was conducting a test of the three Inertial Measurements Units (IMU), the number two unit failed its testing sequences. Although the orbiter can fly with only one IMU if necessary, the decision was made to scrub the launch for 2 February and replace the failed IMU.

The launch was recycled to the T-11 hour period and during the evening of the 1st the IMU was removed and replaced. The new launch target was set for 3 February at approximately 12:22 am. Due to orbital parameters the launch window moved about 25 minutes earlier each day (coincidentally, if the rescheduled 3 February launch had been scrubbed for weather and reset the next opportunity would have been a few minutes before midnight on the same day - giving the launch two opportunities on the same calendar date). During the scrub operation three of the middeck experiments which had strict late installations requirements were refurbished to keep their specimens and samples as fresh as possible for microgravity conditions.

Following the resumption of the launch countdown the remainder of the count went as planned. The weather also cooperated and as the T-0 point approached no problems surfaced to threaten the launch. At 10:50 pm on the 2nd the final Mir state vectors were determined and the launch window was finalised as from 12:22:04 am on the 3rd to 12:27:04 am.

The final T-9 minute hold, based on



Discovery is launched from Pad 39B on 3 February 1995 into an orbit to take it to the Mir space station. NASA

the final launch time calculations, extended for 41 minutes and 15 seconds. Terminal count proceeded successfully and the STS-63 launch of Discovery occurred precisely at the opening of the launch window.

Space Shuttle Main Engine #3 started at 12:21:57.446, followed by SSME #2 at 12:21:57.553 and SSME #1 at 12:21:57.675. Actual Solid Rocket Booster ignition time was 12:22:03.994 am. The launch ascent was a 51.6 degree inclination angle flight path. The Solid Rocket Boosters shut down at launch plus 125 seconds. The main engines reached an average specific impulse of 452.6 seconds between booster separation and main engine throttle down. Main engine cutoff came at launch plus 511.1 seconds.

During the ascent, Reaction Control System (RCS) thrusters L2D failed and R1U indicated minor leaks. The RCS thrusters have redundancy and the problems were not expected to have a serious impact on the flight.

Following the main engine shutdown, the External Tank separated from Discovery and residual propellants in the main engine propulsion system were dumped. The OMS engines fired for approximately 2 minutes and 23 seconds at 42 minutes into the mission and Discovery was orbiting on its 20th space flight.

Rockwell's Space Shuttle Main Engine

With the launch of STS-63, the Space Shuttle Main Engines (SSME) built by Rockwell Aerospace passed a major milestone with more than 200 engine flights.

There have now been 67 completed shuttle launches since the first shuttle lifted off in April 1981. In addition to two boosters, each shuttle relies on three Rockwell engines to propel it into orbit, so STS-63 marked 201 completed engine flights for the SSMEs. The 26 main engines manufactured at Rockwell's Rocketdyne Division have achieved a 100 percent mission success rate during 14 years of service with NASA, lifting more than 40 percent of all the world's payload weight into orbit. The engines have also been subjected to more than 630,000 seconds of tests - equivalent to 1,212 engine flights - making it the most tested rocket engine in history.

Often cited as the most complicated machine ever built and one of America's greatest technology achievements, the SSMEs operate at greater temperature extremes than any mechanical system in common use today and are built with finer tolerances than a Swiss watch. When the liquid hydro-

gen and liquid oxygen are combusted, the temperature in the main combustion chamber is 6,000°F, higher than the boiling point of iron. The energy released by all three engines at full power level is, in units of watts, equivalent to the output of 23 Hoover Dams.

Space Shuttle engines start and shut off at intervals 120-thousandths of a second apart; the intervals prevent unnecessary stress to the orbiter and engines that would otherwise occur with simultaneous starting and stopping.

On start-up, the engine in the No. 3 position fires first, followed by the No. 2 and then No. 1. They shut down in opposite order. Thus, the No. 2 engine is the second engine both to start and shut down. With mission STS-63, main engine 2109, located in the No. 2 position in the orbiter's boat tail, completed engine flight No. 200. The 199th engine flight goes to main engine 2029 and the 201st flight to engine 2035.

Mission Operations Day-by-Day

Flight Day One

Flight controllers at the Mission Control Center at Houston continued to keep a close eye on the thruster leak in the aft right side Reaction Control System (RCS). The thruster leak was a manageable size leak with the loss of 1-2 pounds of propellant per hour. Although thruster leaks are not an uncommon occurrence on Shuttle flights, the thruster leak on STS-63 was more of a concern due to the planned rendezvous with Mir. Flight rules for the mission dictated that Discovery must have all of its aft firing thrusters operational prior to moving within 1,000 feet of Mir.

Flight controllers continued to evaluate the situation as the planned rendezvous sequences continued and Mission Commander Jim Wetherbee performed manoeuvring engine firings. At 7:30 am (all times KSC times) Discovery was about 7,000 miles behind the Russian space station.

On board, the crew had opened the payload bay doors and prepared their orbiter for the scheduled mission operations. They checked out the robotic Remote Manipulator System (RMS) arm, which would be used in the SPARTAN-204 operations, and began their first sleep period as scheduled at twelve hours MET with Discovery in a 189 by 180 nautical mile orbit of 51.6 degrees.



Eileen Collins at the pilot's station during the hot-firing procedure to clear a leaking thruster prior to rendezvous with Mir. NASA

Flight Day Two

During the day, Discovery continued to close on Mir and by 9:30 on the morning of 4 February was in a 200 by 182 nautical mile orbit approximately 4,400 miles behind Mir.

Overnight on 3-4 February the crew deployed the Orbital Debris and Radar Calibration Spheres experiment from a container in the payload bay. A few minutes before midnight three spheres and three dipole wire strand targets were released. The spheres consisted of a 2-inch stainless steel and 4 and 6-inch aluminium spheres. The dipoles were one 1.74-inch and two 5.255-inch platinum alloy wires. These targets will be used to calibrate ground-based

radars in order to help track the thousands of pieces of man-made space junk now orbiting the Earth. The targets will remain in orbit for times of 20 to 280 days.

Mission Specialist Vladimir Titov used the RMS arm to lift the SPARTAN-204 satellite out of the payload bay for several hours. The satellite's ultraviolet instrument was used to study the Shuttle glow effect which is created in low Earth orbit by the interaction of residual atomic oxygen and the spacecraft's surfaces. The satellite was reberthed in the payload bay following these studies. Later in the mission the SPARTAN-204 satellite was deployed for two days of astronomical studies.

Mission controllers at Houston continued to assess the leaking thruster jet issue. A forward thruster (thruster F1F: the first F means it was in the forward group of thrusters, 1 means manifold # 1, and the last F means the thruster exhaust is towards the forward) began leaking following a hot fire test earlier in the day. Mission planners were working on techniques that would allow the Mir rendezvous to proceed safely.

The crew were active with the Spacehab-3 experiment suite and began Bioserve Pilot Laboratory (BPL) operations studying cellular/genetic changes in bacteria. Although past mission experience with this class of hardware had resulted in minor leakages within containments, no leakages were found this time. Warm Spacehab temperatures caused minor temperature excursions in the 4 degree Commercial Protein Crystal Growth (CPCG) unit, however the crew lowered the cabin temperatures and the operations returned to nominal values.

Overnight, with activation at 1 day, 9 hours, 4 minutes of MET, the furnace in the Equipment for Controlled Liquid Phase Sintering Experiment (ECLIPSE) successfully performed a melt and defect-trapping exercise with deactivation at 2 days, 42 minutes of MET.

Shuttle Robot Under Test

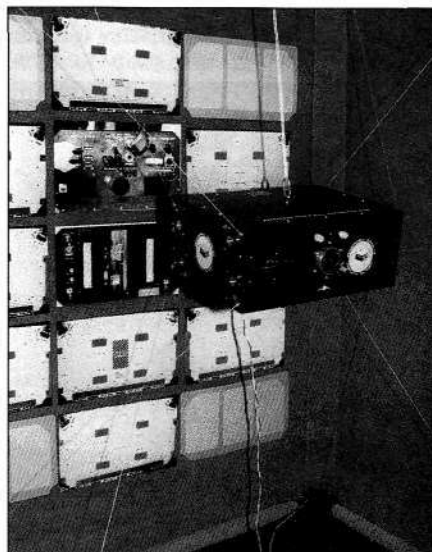
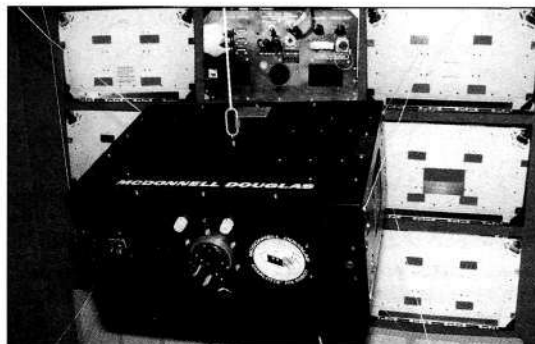
The Charlotte robot, built by McDonnell Douglas, made its first space flight on STS-63 for evaluation for future shuttle flights and space station use.

Equipped with a video camera and an arm with a simple gripping device, Charlotte can be controlled from Earth to turn knobs, flip switches, pick up objects, exchange experimental samples and perform other inspection and manipulation tasks. In automatic mode, it becomes an extra crew member capable of performing as the crew sleeps.

Resembling a spider spinning a web, the robot inspired its creators to name it "Charlotte" after the spider in the children's book, *Charlotte's Web*.

Above and Right: A prototype of Charlotte under demonstration at KSC displays its ingenious design. Using eight non-stretch cables and eight stepper motors, this relatively inexpensive machine can move in all three axes and rotate about each. It is extremely rigid in any position and can repeat any movement with the highest precision. It has the ability to flip switches and change experimental samples.

PETER GUALTIERI, WEST KENTUCKY NEWS





Michael Foale (left) and Bernard Harris prepare suits prior to their spacewalk.

NASA



The inflight crew press conference on 10 February at which a reporter from shuttle pilot Eileen Collins' Elmira, NY hometown paper asks her a question.

PETER GUALTIERI, WEST KENTUCKY NEWS



The right-hand booster on 6 February after its recovery and a delayed return to port due to rough seas in the drop zone. Three large dents are seen along the booster.

PETER GUALTIERI, WEST KENTUCKY NEWS

The STS-63 crew depart KSC for Houston on 11 February. Seen here on the "Skid Strip" are spacewalkers Bernard Harris (left) and Michael Foale (right) with Vladimir Titov (centre).

PETER GUALTIERI, WEST KENTUCKY NEWS



Flight Day Three

Flight control teams at Houston and at the Russian control centre in Kaliningrad continued to assess the rendezvous operations and refine the final plans. The rendezvous was set for the following day as managers worked towards a consensus on the issue of the leaking thrusters.

Mission Commander Jim Wetherbee and Pilot Eileen Collins closed and reopened the manifold leading to the thruster several times. This procedure was successful in stopping the leak in the thruster located on the orbiter's nose. It was not successful, however, with the thruster on the right rear area.

Mission experiment operations continued during this period. Spacehab operations included the use of the "Charlotte" robot. The robot, named after the spider in the children's story of the same name, consists of a unit supported by a web of cables. The cables are easily installed and removed within the Spacehab module and the Charlotte moves along the cables so as to bring it to its desired position. The robot is used for turning knobs, throwing switches and performing routing operations and inspections when the crew are not available.

The crew also activated the Solid Surface Combustion Experiment which studied the process of burning in microgravity. In this instance the material being studied was Plexiglas. This was the eighth time this experiment had been flown on a Shuttle mission.

Rendezvous flight operations continued and at 6:00 pm Discovery was about 1,000 nautical miles behind Mir and in a 208 by 197 nautical mile orbit. The closing rate during that period was about 78 miles per orbit. Flight control teams continued to assess the thruster leak to determine if it would be safe to close the manifold leading to the thruster and continue to approach the space station to within the planned distance of approximately 11 metres.

UK Checks Radiation in Orbit

A set of radiation detectors were provided by the Space and Communications Department of the Defence Research Agency at Farnborough, Hants for the Cosmic radiation Effects and Activation Monitor (CREAM) experiment aboard STS-63 and carried into space using lockers in the Spacehab module. The monitors are designed to count both the penetrating cosmic radiation, which permeates the galaxy, and the less energetic radiation encountered in the lower fringes of the Van Allen radiation belts through which Discovery passes over the South Atlantic. These radiations cause upsets in computers used in space and limit the amount of time which astronauts can safely spend in orbit.

Flight Day Four

The primary objective of the day's operations was the rendezvous with Mir. Discovery fired its manoeuvring engines at 9:16 am and again at 10:02 am to decrease the closing rate of approximately 79 miles per orbit.

Meanwhile, flight controllers at Houston and Kaliningrad had fully assessed the implications of the leak of the rear aft thruster and determined that the rendezvous could be successfully continued to the close approach position without the use of the thruster. At 10:25 am the crew were given a "go" for the close approach. Valdimir Titov was already in radio contact with his countrymen aboard Mir.

With the Shuttle about 8 nautical miles from Mir at 11:37 am, Discovery again fired its engines to begin the final phase of the rendezvous which brought the orbiter to a point 400 feet ahead of the Mir at about 1:16 pm.

Discovery then moved down the velocity vector toward Mir and when a point 100 feet from Mir was reached a hand held laser range and rate instrument provided additional data on the relative positions of the two spacecraft as did the Trajectory Control Sensor (TCS) laser mounted in the payload bay. Five television cameras in the payload bay aided Mission Commander Wetherbee as he approached Mir: two were on the Spacehab aft bulkhead, two on the payload bay aft bulkhead and one in a window in the top of the Spacehab module.

During the final approach Wetherbee brought Discovery to a distance of 37 feet from the Mir's Kristall docking module by approaching at a rate of about 0.1 foot per second. Wetherbee aligned the orbiter to the docking module with the camera in the Spacehab window. The Russian crew aboard Mir were controlling their space station during the rendezvous to maintain the orientation. The rendezvous was performed over the Eurasian land mass so as to allow constant communication between Mir and their ground mission control station. The two spacecraft were at an altitude of about 213 nautical miles.

As Discovery reached its closest approach point, Mission Commander Wetherbee said "As we are bringing our space ships together, we are bringing our nations closer together. The next time we approach, we will shake your hand and together we will lead our world into the next millennium". Wetherbee reported Discovery

handled well during the approach operations.

Both Discovery and Mir crews sent down television images of each other's spacecraft and observers on the ground could clearly see the crew members waving to each other. Discovery remained on station at the close approach point for about 10 minutes and then initiated a pull-back to the point 400 feet ahead of the Mir. Wetherbee then flew around Mir at a

to grapple the SPARTAN-204 satellite in the payload bay and to raise it up off of its support carrier. He then lifted the satellite out of the payload bay and released it at 7:26 am. Discovery then moved away from the satellite, which spent the next two days making studies of interstellar gas and dust. SPARTAN-204's Far Ultraviolet Imaging Spectrograph made observations which were recorded aboard the satellite for later analysis following the mission's return.

Flight Day Six

Mir and Discovery commanders talked to each other during a special spacecraft-to-spacecraft hook-up via an interpreter in Houston's Mission Control Center. Wetherbee said he especially enjoyed the point in the operations when Mir manoeuvred to a new attitude while Discovery was circling it. "It was like dancing in the cosmos", Wetherbee said. "It was great". The commanders said they were looking forward to meeting again on Earth and exchanged complements about the two space vehicles and the teams that designed them.

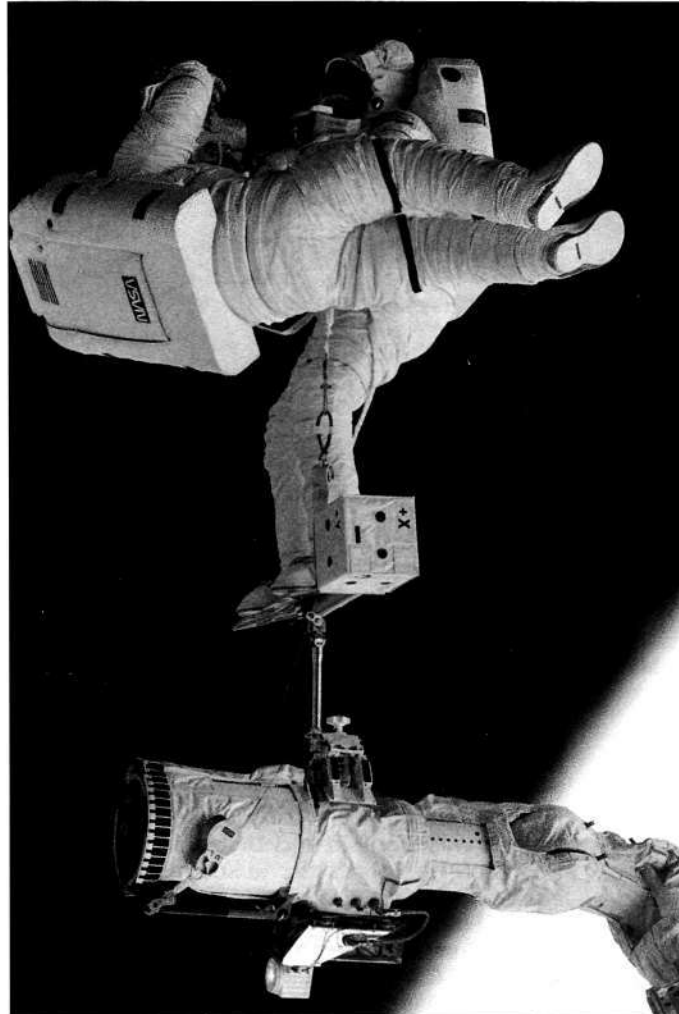
Payload Commander Bernard Harris and Mission Specialist Mike Foale spent several hours unstowing and checking the spacesuits they would use in the following day's spacewalk.

Flight Day Seven

Discovery's crew performed the second rendezvous of the mission as Mission Commander Wetherbee and Pilot Collins flew the orbiter to the SPARTAN-204 satellite. Janice Voss used the RMS arm to capture the grapple fixture on the satellite at 6:33 am as Discovery flew above the Pacific Ocean.

Bernard Harris and Mike Foale began a spacewalk designed to test new thermal devices for their spacesuits and to test their handling of the 3,000 pound SPARTAN-204. The astronauts floated into the payload bay at 6:56 am and mounted the RMS arm which Valdimir Titov positioned so that the spacewalkers would be high over the payload bay and away from any heat. They stayed in that position for about 15 minutes to subjectively rate their comfort levels as sensors in the gloves collected data to be compared to the space environment around them.

For the second part of the spacewalk, Harris conducted a mass handling exercise with the SPARTAN-204 satellite to gain experience in moving



Bernard Harris stands on a foot restraint attached to the Remote Manipulator System (RMS) arm during his joint spacewalk in Discovery's cargo bay with Michael Foale.

NASA

distance of about 450 feet to allow for photographic documentation to be used in planning future rendezvous and docking missions.

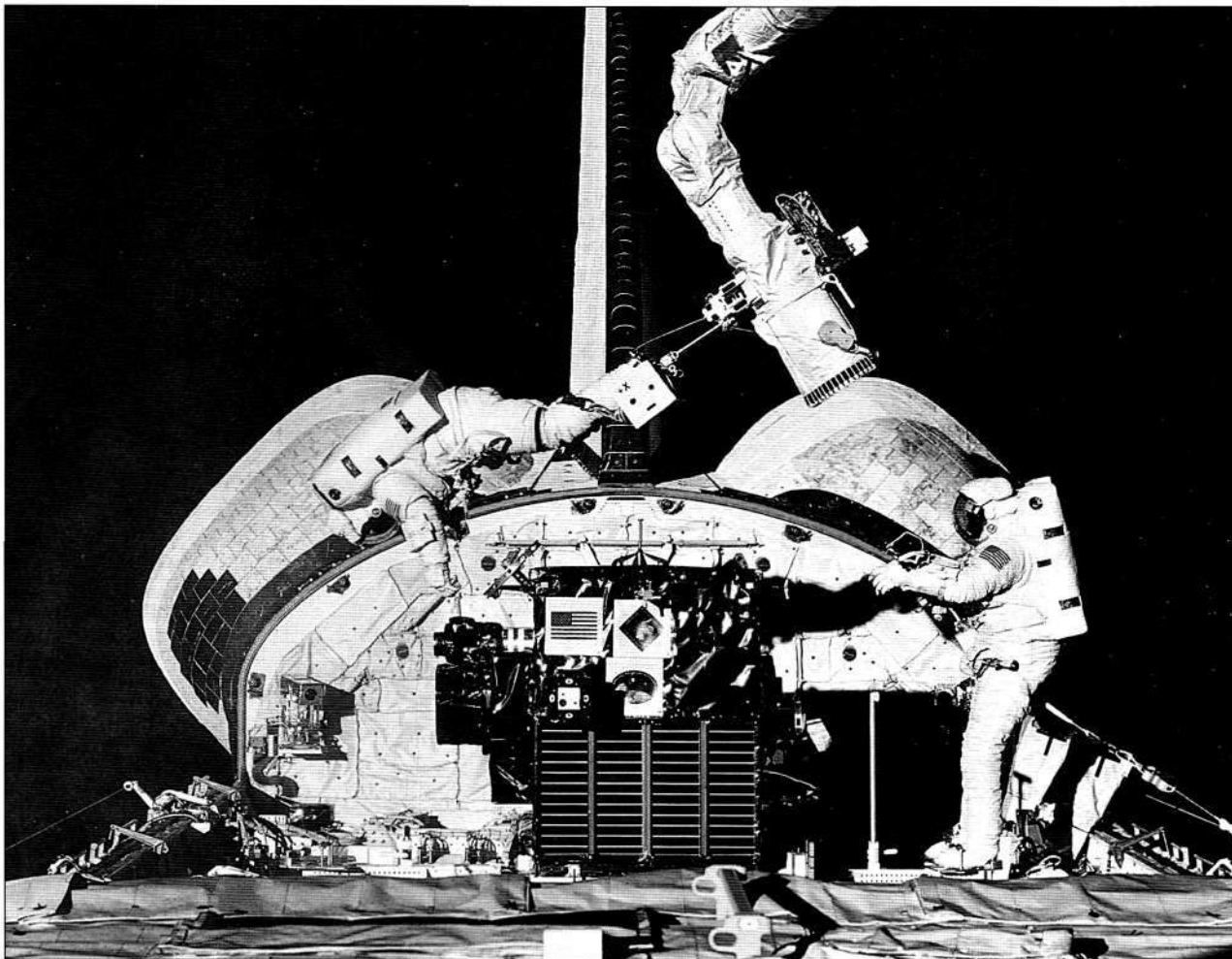
Mir Commander Alexander Viktorenko reported that the orbiter's thruster firings did not affect Mir's solar arrays. The experience of the day's operations will be used in planning the first Shuttle-to-Mir docking on mission STS-71.

At about 4:13 pm Discovery fired its manoeuvring engines to depart the rendezvous area.

Flight Day Five

Following their historic rendezvous, the crew turned their attention to experimental studies and a satellite deployment.

Vladimir Titov used Discovery's RMS



Michael Foale on the Remote Manipulator (RMS) arm is preparing to grab the SPARTAN-204 satellite as Bernard Harris looks on. NASA

large objects on orbit. As the exercise was being finished, both astronauts reported their hands were becoming cold and mission controllers decided to cancel the mass handling exercise which had been planned for Foale. The spacewalk, the 29th of the Shuttle programme, lasted 4 hours and 39 minutes.

Flight Day Eight

Final experimental work and preparations for landing characterised the eighth day of the mission. Observations of the Shuttle Glow effect were made as Commander Wetherbee and Pilot Collins fired the thrusters to allow the instrument to observe the effect of the firing on the glow phenomenon.

Final Spacehab experiments were wrapped up and the module was deactivated at about 8:30 am.

Shuttle astronauts took a last look at the Mir space station. At about 1:35 pm Mir performed an on-orbit manoeuvre during which the STS-63 astronauts reported they could see it near the horizon. At 815 miles distance Mir looked like a small flashing star to the payload bay cameras.

Flight Day Nine

The mission came to a close as planned. The crew were awakened at about 11:43 pm on the 10th and at 1:44 am on the 11th deorbit preparations began.

At 3:04 am the payload bay doors were closed. The deorbit engine burn was at 5:44 am.

The weather at Kennedy Space Center was perfect and Discovery's approach was northwest to southeast across the North American continent.

The landing occurred 14 minutes before sunrise with main gear touchdown at 6:50:19 (8:06:28:15 MET), nose gear touchdown at 6:50:33 and wheel stop at 6:51:39 am on runway 15.

The landing, on orbit 130, completed a 2,992,000 miles flight of 8 days, 6 hours and 28 minutes.

After the crew had left the orbiter, Discovery was towed to the Orbiter Processing Facility to begin its preparations for its next mission - STS-70.

Coca-Cola in Space

Canned Coke has been in space before, but aboard STS-63 it was available chilled and from a fountain in its two varieties - regular Coke and Diet Coke.

The 'experiment' was sponsored by the Coca-Cola Co. as a taste test and as a way of developing better-tasting space beverages. New technology involved the operation of a space fountain and how gas and liquid separate under weightless conditions.

While drinking Colas, the astronauts aboard STS-63 used a small, hand-held

monitor and finger tip sensor to measure changes in their heart rates as they drank. The unusual experiment was supported by Ohmeda, a health care company specializing in anaesthesia and critical care, and it employed Ohmeda's new hand-held pulse oximeter, a blood oxygen monitor that is more apt to be used in a hospital than a space shuttle. The Shuttle experiment focused on the physiological changes that astronauts experience during weightlessness and how these changes create orthostatic intolerance (i.e. difficulty in standing erect) when they return to Earth. This is a common condition in older people and results in dizziness and fainting due to shifting blood volume when a person stands quickly. But how might Cola drinking in space keep older earthlings from fainting? "It's all related to changes in our heart rate when we drink something," according to Louis Stodieck, who is coordinating the experiment and is associate director of BioServe Space Technologies, a NASA Center for the Commercial Development of Space, located at the University of Colorado, Boulder. "When we drink, a response is automatically triggered through the nervous system to increase the heart rate, and with the help of Ohmeda's OxySTATM Plus hand-held oximeter and OxyTipR sensor, we'll be collecting heart rate and blood oxygen saturated data to compare astronauts' heart reflex mechanisms under weightless conditions to data taken preflight. After studying the changes that occur, we hope to develop countermeasures to prevent orthostatic intolerance in astronauts following space flight, which may be applied to people suffering from it here on Earth." ■

There's no Soy Fuzz in "Soyuz"

To pronounce names correctly, particularly personal names, is not unimportant. Many Russian space names are fairly straightforward, but others are tricky for the unsuspecting and an incorrect pronunciation at the wrong time could be a big let down. So it is as well to know right from wrong and James Oberg, who is conversant in Russian, is ready to help out.

In the delightful film "Young Frankenstein", Marty Feldman (as Igor) insists to Gene Wilder (as Dr. Frankenstein) that his name be pronounced the way he wants, and he wants it to sound like *Eye-Gore*. But anyone who knows their Tolstoy realizes that real Russians pronounce it *Ee-Gore*. And in the final analysis, the people who own the names should determine how they are pronounced.

So it is a good sign that Americans working the US/Russian space deal have gradually been getting their Russian pronunciations right. People rarely say *MURR* for Mir (*Meer*) any more, although they still tend to capitalize it all (*MIR*) as if it were an acronym and not simply a proper noun.

And many Russian space names are fairly straightforward, with a common sense American-eared "first guess" being fairly close. That works fine for names such as Progress, or Raduga, or Zenit, or Kvant, Kristall, Priroda, and Spektr - even though the stressed syllable does not always come out quite right.

But "Soyuz" is a problem. The "y" is deceptive. In the standard orthography for transliteration from Cyrillic into Latin letters, the "yu" stands for a specific Russian letter, so it cannot be split. This makes the syllables So-Yuz, not Soy-Uz.

There is a lot of leeway in pronouncing each syllable. "So" with a long "o" seems straightforward, but since the spoken stress is on the second syllable, Russians tend to slur the unstressed "o" into a neutral "ah". "Yuz" has a long "u", in "ooze", not a short "u", as in Buzz. Also, in speaking, voiced final consonants tend to become unvoiced (the "z" shifts to more like an "s"), but this is not too important.

Try: for "Soyuz", say *sah-YOOZ*, or if you are more ambitious, *sah-YOOSS*. But please, drop the "Soy" Sauce, and do not make Soyuz rhyme with Coy Fuzz.

This troublesome "y" always used to confuse Jules Bergman, the ABC-TV space reporter. Whenever he talked about the Soviet launch site at Tyuratam, he made it four syllables: *TIE-YOUR-A-TAM*. It was supposed to be *T'YOU-Rah-TAM*, only three syllables. And since the Soviets deceptively called it "Baikonur" decades ago, people have got used to using the false name anyway.

Why does it matter? Proper pronunciation of other people's names is always a sign of respect and it will be appreciated. It is worth the effort.

BY JAMES OBERG

Texas, USA

Another example: generations of English-speakers pronounce Vladimir and Boris with stress on the first syllable. Russians stress them on the second syllable. It may not seem like a big difference but try shifting stress on some American multi-syllabic first names and see how it grates on our ears.

Even though Sergey Krikalev is a very diplomatic and easy-going man, and has probably got used to Americans mispronouncing his name, try getting it more authentic. His name ends in a variant of "e" that sometimes has an umlaut over it and is pronounced *yoh* or *yaw*, and is always the stressed syllable. So it is not *KREE-kall-ev*, it is closer to *kri-kal-YOFF* (remember how voiced consonants become unvoiced at the ends of words). The same goes for STS-71 passenger Anatoliy Solov'ev (*sah-lav-YOFF*), Moscow MCC ("TsUP" with a long "u") deputy Vladimir Solov'ev (*vla-DEEM-er sah-lav-YOFF*), Soviet space program founder Sergey Korolev (*kah-rah-l-YOFF*), and even ex-premier Nikita Khrushchev (*khroosch-YOFF*).

"Energia" has a hard "g", to rhyme with Carmen Ghia. And they have changed the initials from "NPO" to "RKK" when they privatized in mid-1994. Meanwhile, that e-umlaut letter also appears in the middle syllable of RSC Energiya's director, Yuri Semenov (so the proper pronunciation is *Simm-YAWN-off*), and also with chief RKK-E interpreter Boris (*ba-REESS*) Artemov (*art-YAW-moff*).

"Buran" has a flat "a", is in "don", not a wide whiney "a" as in "ran" or "Anne". The "u" is long (*boor*), not short (*burr*). And stress the second syllable. As the ancient Romans said, "De mortuis nil nisi bonum" (look it up).

Do not confuse "Kazakh" and "Kazak" - the first is the ethnic Turkic inhabitants of Kazakhstan, and the second is the Russian word for "Cosack", ethnic Slavs who were famed horsemen. Kazakhs now own Baikonur, so treat them nicely.

From old "Space Race" history, there is the "Voskhod", often mispronounced (and sometimes even misspelled) as *VOSH-kod*. Stress the second syllable and say it *vahss-KH'OTE*, to rhyme with "Vostok" (*vahss-TOKE*). And going way back, the "u" in "sputnik" is long, as in "spook", not short, as in "sputter".

About the Author



James Oberg

James Oberg, by day a senior space engineer in Houston specializing in orbital rendezvous, continues to pursue his life-long interests in the Russian space programme's past, present and future as a private, independent author, consultant and commentator. In recognition of his research into Russian space history and his visits to the Baikonur Cosmodrome, he has been formally awarded the medal, "Veteran of Baikonur", by the cosmodrome workers' alumni organization. While there for the recent Soyuz TM-21 launch he also met with cosmodrome commander Shumilin and Leninsk mayor Dmitriyenko as part of a newly commissioned research project on the prospects for Russian cosmonautics.

The rocket and the communications satellite called "Molniya" are pronounced *MOLE-nee-ya*, not "*mole-NY-a*" with a long "i" in a stressed second syllable.

The Russians call their cosmonaut training town Zvyozdnyy Gorodok, or "Starry Town". Back in ASTP days it came to be called "Star City", a somewhat too overblown term for its municipal and celestial status, but the misnomer has stuck. It can be referred to simply as "Zvyozdnyy" (pronounced *Z'V'YOZ-nee*), or *ZG* - or you probably can go with the common, unambiguous usage and stick with Star City, since it is so widespread there is probably no stamping it out. And please, also, there's no second "R" in Gagarin (no more Gargarin, please!).

Again, why bother to try to get these little things right? Getting them right marks you as somebody who takes the trouble to understand other people and other cultures, and it places you among the real "cognoscenti" (pronounced, of course, *cone-yah-SHEN-tee*) of Russia and its space program. Getting it wrong might suggest the opposite, I would humbly suggest. Take your choice. ■

One-page 'INTO SPACE' articles offer readers the opportunity to express their ideas and 'think aloud' on topics which they see as important and of interest to others. Contributions of an appropriate (one-page) length may be sent to the editor at any time and should be accompanied with a photo of the writer (head and shoulders) and a few lines of personal details.

Russian Space Shuttle

BY PETER PESAVENTO

California, USA

There is an old Russian folk-tale about a young woman named Marushka who was famous for being able to embroider fantastical designs, which she sold at whatever price the buyer thought the work was worth. Her ability to create beautiful things caused men far and wide to fall in love with her and to propose marriage. She turned them all down, wanting to remain in the village where she was born. Her fame reached the ears of an evil sorcerer named Kaschei the Immortal, who thought that with his magic powers, he could persuade her to go away with him. She modestly turned down his offer as well. Enraged, Kaschei turned her into a fire-bird with brilliant plumage and himself into a huge black bird of prey. The bird of prey instantly seized the fire-bird in its cruel talons, and flew away. Marushka, recognizing her lifeblood ebbing away, willed that she would shed her plumage. Her feathers fell to the ground on the land she loved. Although Marushka died, her feathers were magical - for they remained alive, but only to those who appreciated beauty and chose to share it with others.

The fire-bird tale closely parallels the history of the Russian effort to fly winged vehicles in space. For nearly four decades, the Russians have dreamed of populating near-Earth space with crewed aerospace craft. Only in early February, 1994, when the US Space Shuttle Discovery lifted off from Cape Canaveral on the 60th American Shuttle mission, did the Russian dream become reality - Sergei Krikalev (who did not train to fly space shuttles) became the first of his countrymen to view the Earth from the flight deck of a winged space vehicle.

Until quite recently, the breadth and scope of a space shuttle programme conducted by America's arch rival eluded most scrutiny even by the best efforts of Western intelligence - two National Intelligence Estimates on the Soviet space programme authored by

the CIA only peripherally mention the possibility of such activities in the 1962 edition, while in the 1967 version no mention is made at all. Due to the recent relaxation of secrecy rules in the former USSR, previously classified space archives have revealed a very concrete commitment to winged manned space ships, although there is still confusion and contradictory information being released on many of the projects (for example, the exact dates when projects were begun and terminated). The mostly secret, sometimes overt - yet wholly military - effort tells a distinctly Russian story. Sadly, promising technologies demonstrated by nearly 20 shuttle projects were - like the folk heroine Marushka - allowed to wither away: through Politburo interference, political squabbling among rival design bureaus, as well as by

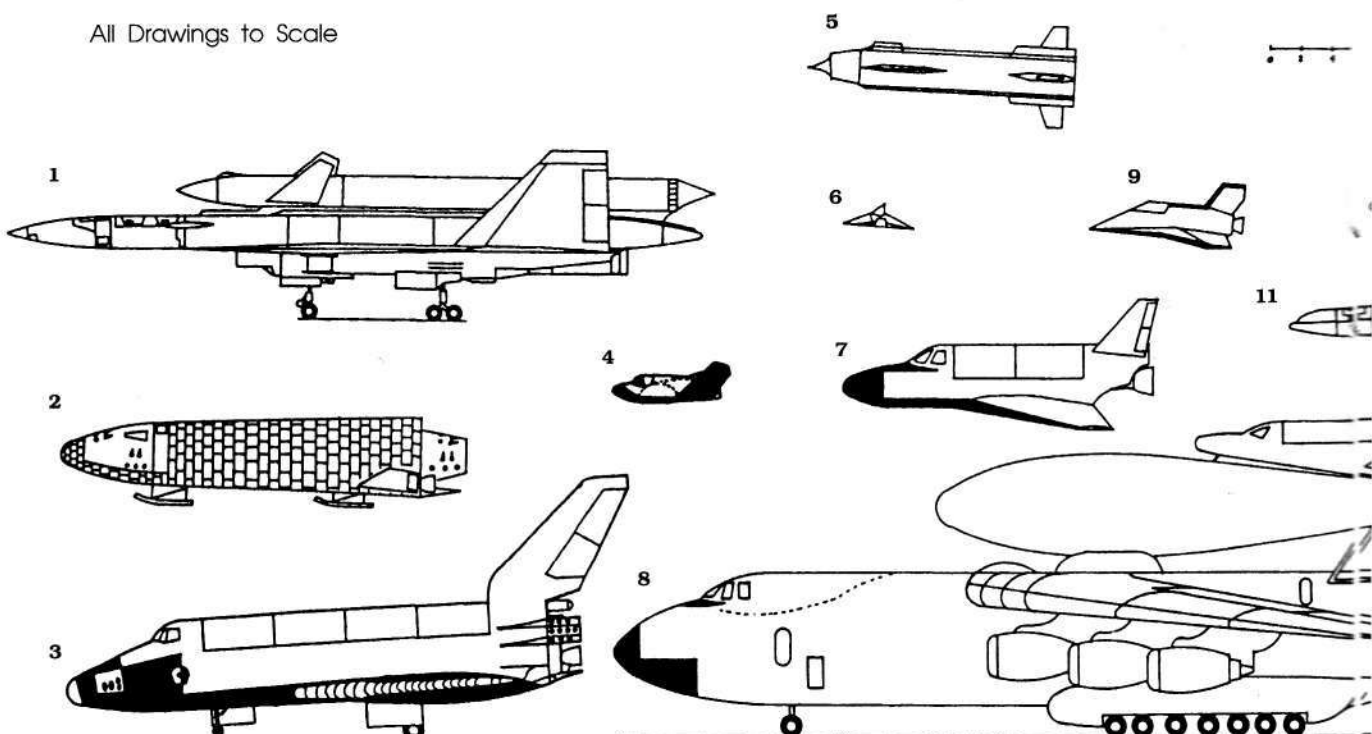
changing military requirements.

Archives reveal a multitude of project names and acronyms, among them: VKA-23, Burya, IGLA, EPOS, Uragan, BOR, Buran, Spiral, Kosmolyot, MAKS, and Project 48. The winged vehicles ranged in size from four to 90 meters in length. According to the best evidence available, apparently several times - in 1960, 1965, 1978 (or 1979), and in 1987 - space shuttles that were capable of being launched into space with a crew on board were built, only to wait in vain for final approval for an actual launching into space from Soviet political authorities. But perhaps Westerners (and especially Americans) should be thankful: for all the projects ultimately had Cold War purposes. The mission aims included close-up inspection of non-Russian satellites, the interception and destruction of crewed US Space Shuttle flights slated for launching from Vandenberg Air Force Base in California, and the nuclear bombing of cities from orbit.

But despite the blind alleys followed in their shuttle projects due to Politburo ambitions, the Russians achieved several technological firsts and innovations: star-tracking navigational systems for course correction in a near-hypersonic vehicle (1957); contour-fol-

Russian Space Shuttle/Space Plane Projects (and precursors): 1. Sukhoi OKB Competition entry for the Spiral project mid-1960s; 2. NPO Energiya Reusable Vertical Landing Transport ("Glushkolyot") 1974-1976; 3. NPO Molniya/NPO Energiya Buran Space Shuttle 1974-1993; 4. MiG OKB/NPO Molniya Hurricane Space Interceptor 1980-87; 5. Lavochkin OKB Burya Cruise missile 1954-1960; 6. Myasischev OKB First Soviet Shuttle Design 1957; 7. Chalomei OKB Space Interceptor Competitor to Buran (built in one month) late 1970s; 8. MAKS Space Plane with Antonov 225 launcher NPO Molniya/Antonov OKB 1988-Present;

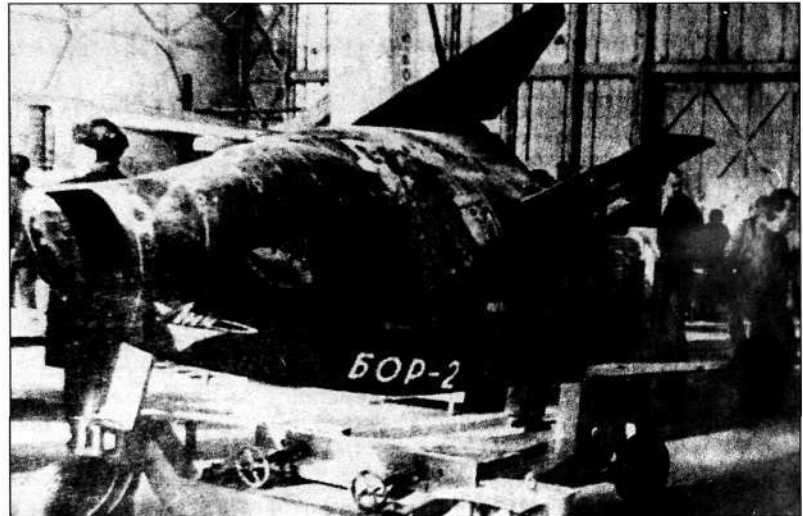
All Drawings to Scale



Projects, 1957-1994 - Part 1

lowing heat-shield materials capable of withstanding temperatures of up to 1400°C, including: columbium-alloy tiles filled with foam ceramic (1959); quartz-fibre tiles (1960); and high-cobalt-content, stainless-steel-alloy chain mail with ceramic backing (circa 1968); ejection seats capable of rescuing cosmonauts from a troubled shuttle craft at speeds up to Mach 4.1 and 34 km altitude (1989); and flight tests of supersonic-combustion ramjet engines that could be used to take a shuttle from atmospheric flight into orbit (1991).

The Russians may yet achieve their dream of viewing the Earth from an indigenously built winged spacecraft. Outgrowths of military projects that began under Communist rule appear to be bearing civilian fruit, albeit at a slower pace and more precariously in Russia's hyper-inflationary economy (in 1993, inflation approached 1000%, while in 1994 it was about 600%). Besides the above-mentioned scramjet tests launched from a pad in Kazakhstan, the Tupolev airplane design bureau in Moscow is conducting low-level work on the Tupolev 2000 - an aerospace plane that would take off horizontally under its own power and fly into space. This project is directly descended from a crash Soviet project during the 1980s to build such a craft in competition with the USA's now-cancelled X-30. Furthermore, in a joint effort between Russian and



A photograph of BOR-2 that was on display at a Red Air Force exhibition, unknown date and place. This was part of the suborbital tests conducted during the late 1960s for project Spiral, the first serious effort to develop a space interceptor. GRIGORI OMELCHENKO

Ukrainian aerospace firms, development beyond the design stage of a mini-shuttle launched from the back of an Antonov transport aircraft is continuing - indications that, by the 21st century, the former Soviets could realize plans begun in the 1950s.

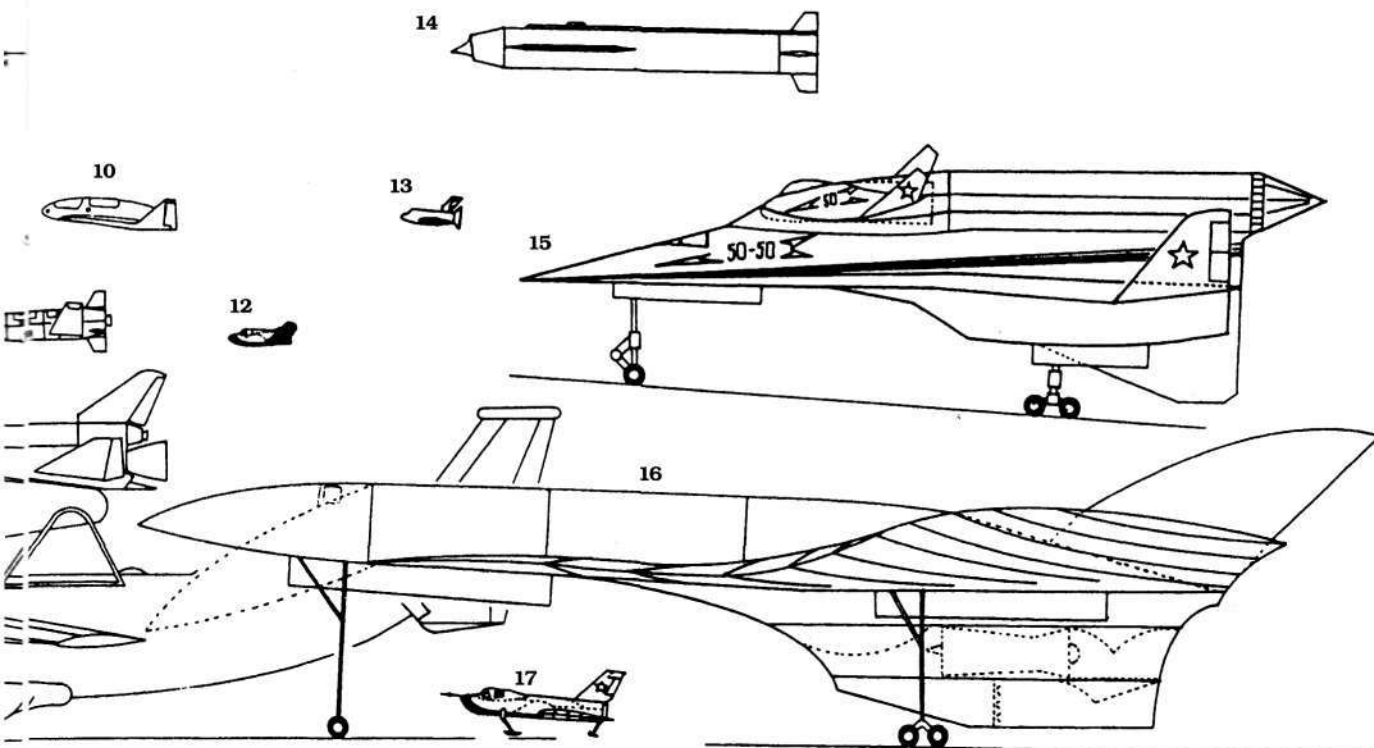
Military Origins

In 1958, the Soviet Defence Ministry produced a plan that outlined the main direction of the Red Air Force for the next quarter century. The plan included development of Kosmolyots (space aircraft), airplane-like vehicles

that could operate at extremely high altitudes, and in the vacuum of near-Earth space. The contemplated development of these vehicles was foreseen to ultimately achieve speeds beyond Mach 10, at altitudes well over 60 km (it is considered that 72 km is the lower limit of orbital altitude).

But despite the mandate that Kosmolyots be test-flown within 25 years, there was no technological base on which to build. In theory, the propulsion systems to send the space aircraft into orbit and materials that would help the vehicles withstand

9+10. Myasishchev OKB Competition Entries for the first Soviet Shuttle 1959-1960; 11. Tsybin OKB Competition Entry for the first Soviet shuttle 1959-1960; 12. NPO Molniya BOR-4 1982-1984; 13. NPO Molniya BOR-5 1983-1988; 14. Myasishchev OKB Buran Cruise Missile 1953-1957; 15. MiG OKB Competition entry for the Spiral project 1961-1972; 16. Tupolev OKB Soviet Aerospace Plane Design 1986-1991 (Possibly still funded at low levels); 17. MiG OKB Article 105.11 (Spiral subsonic crewed testbed) 1974-1978. NPO - Scientific/Technical Association; OKB - Special Design Bureau.



reentry temperatures into the Earth's atmosphere were feasible, but not yet developed. The task of creating the technology base fell to the Opytno Konstruktskoe Byuros ("OKBs", or "Special Design Bureaus"), institutes where scientists and engineers worked as part of the Soviet military-industrial complex. OKBs were usually given the task of building prototypes for competitions sponsored by the military in the hope of winning the contract to build in quantity. In late 1958, the first competition for a crewed winged spacecraft was formalized as the first step to fulfil the Defence Ministry's mandate.

However, just one year earlier in 1957, the first crewed space plane design was born at OKB-23, an aircraft bomber design bureau headed by Vladimir Myasishchev, who had worked previously on cruise missiles. Although the vehicle was ultimately not built, the porpoise-shaped spacecraft appeared concurrently with the first more-simple designs of the sphere-like Vostok that would eventually send the first men into space. Myasishchev's OKB would be able to put this preliminary effort to good use the following year.

Two special design bureaus were chosen to build the Defence Ministry's first stab at an aerospace plane which was labelled Vozdušno Kosmicheskoye Apparat-23 ("VKA-23," or "Aerospace Vehicle 23"). Myasishchev's OKB-23, as well as Pavel Tsybin's OKB-256

were awarded the contracts. Both design bureaus coordinated their work with OKB-1, a special group that exclusively designed and built spacecraft, that was headed by Sergei Korolev (who is better known as the "Chief Designer" of the Soviet space effort, and was instrumental in early USSR space achievements). The two competing teams of engineers began work in 1959, and the design that the two OKBs ultimately built were vastly different from each other. OKB-256 worked on a prototype that had hinged wings that could change their dihedral (the degree of how much upward inclination a wing has) while flying in the atmosphere for more manoeuvrability (the dihedral angle would change depending on the speed regime during flight). OKB-23 actually built two different, fixed-wing spacecraft - one with a single vertical tail and a faceted body, while the other possessed a twinned tail with smooth contours.

Ultimately, manned missions were slated to be launched using both OKB's space plane prototypes (available information indicates that existing rocket hardware - the R-7 booster - was being considered), but in October 1960 both projects were terminated under Premier Nikita Krushchev's restructuring of the Soviet defence industry, and so the completed craft never flew (much of the life-support and control systems were either the same or based on the equipment used aboard the Vostoks). Both OKB-23 and

OKB-256 were affected by the restructuring, resulting in the design institutes being shut down and absorbed by other surviving engineering groups.

A similar fate befell another shuttle project that would have been the first overtly military spacecraft. In 1960, a new military-oriented missile and spacecraft design bureau was instituted - OKB-52 - headed by Vladimir Chalomei. Soon after the bureau's inception, Chalomei's engineers were assigned to design and build a prototype multi-seat space shuttle that would intercept and inspect American satellites. (It would have had an orbital apogee of 290 km with a mission of only 24 hours duration). Twelve months later, the first full-scale craft called the MP-1 was ready for launching. A unique feature of the MP-1 was its adjustable braking panels that, when fully deployed at the aft of the vehicle, formed the appearance of an umbrella. On 27 December 1961 a successful uncrewed sub-orbital test via an R-12 rocket took place. The craft ascended to a height of 405 km and flew 1760 km down range.

A further full-size craft was built, but this time the engineers called the vehicle M-12. One of the main differences from the MP-1 craft was that the crude braking panels at the aft of the vehicle were replaced by actual aerodynamic rudders and it was instrumented to measure airframe stresses and heat absorption during reentry. The M-12 successfully repeated the MP-1's mission in March 1963. A third flight-ready shuttle (called the R-1) was slated to be launched in late 1964 in anticipation of a crewed mission in 1965 (with an improved space plane version called the R-2), but in October 1964 Nikita Krushchev was deposed and OKB-52 fell from favour for winged spaceflight projects. (According to Chalomei bureau engineers, they claim that because Krushchev's son, Sergei was a deputy design engineer on the team, the shuttle interceptor was cancelled on orders of Leonid Brezhnev, the new Premier). OKB-52's craft never flew again.

Project Spiral

With the demise of Chalomei's project, another competition was held to build a shuttle craft. This time, the two design bureaus chosen to field prototypes had their expertise in jet fighters - one by Pavel Sukhoi, and the other by Artyom Mikoyan, well known for the "MiG" series of fighters. The Sukhoi and Mikoyan teams began development work in 1966. At this time, little is known about the Sukhoi project, other than that the T-4 supersonic experimental bomber aircraft was to have launched the Sukhoi competitor off its back. In contrast, much information has been released about Mikoyan's project, also known as Spiral.

A 'Failed' Project that Did Not

According to official Russian space histories, the shuttle story began in the early 1960s, when the USSR appeared to be in imminent danger of nuclear attack from US bomber aircraft in forward positions near the country's borders. A competition was held for a supersonic uncrewed cruise missile that would be able to strike back at targets deep within the US. The project's characteristics - such as the planned tri-sonic speed, as well as a flight path that skirted the edge of space (30 km) - are reasons mentioned by Russian space historians as to why this project is considered the first forerunner of all space shuttles.

Two aircraft design bureaus, one headed by fighter specialist Semyon Lavochkin (OKB-301), with the other by long-range bomber expert Vladimir Myasishchev (OKB-23), were chosen. Although both design bureaus started development a year apart, it was the Lavochkin OKB (which had started later) that had its craft ready for testing first. Lavochkin's cruise missile was given the name Burya ("Tempest"). For years, the official histories recorded that the testing of the Burya vehicle had ended in failure, which affected the competing Myasishchev's missile (called Buran, or "Snowstorm") as well, resulting in both projects being cancelled.

In late 1992, Lavochkin bureau engineers revealed a different story. They informed US officials that instead of failure the Burya project was completely successful. Five long-range missions between June 1957 and April 1958 were conducted. The flights were made from the Volga river delta to the eastern shore of the Kamchatka peninsula, and back again - a round trip of nearly 8,000 km.

A significant fact about the Burya

project is that it was the first near-hypersonic vehicle to use a celestial navigation system that employed a star-tracker for course corrections. Four of the flights were performed at night, while the fifth was flown during the day to validate the operation of the star tracker in daylight. In contrast, it was not until 1979 that the Americans employed a star-tracking navigation system in its ocean-launched Trident missile (albeit much more sophisticated than that used on the Soviet cruise missile).

Despite Burya's successes, and with the follow-on flight tests of OKB-23's Buran cruise missile imminent, both projects were cancelled. The Politburo decision was to favour ICBMs following the successful launch of Sputnik in October 1957. Buran was cancelled in November 1957, while Burya was allowed to linger until 1960. It is an interesting side note that Myasishchev's bureau planned to have follow-on tests of its Buran missile as a crewed hypersonic demonstrator aircraft, to shed light on medical problems of high-speed flight.

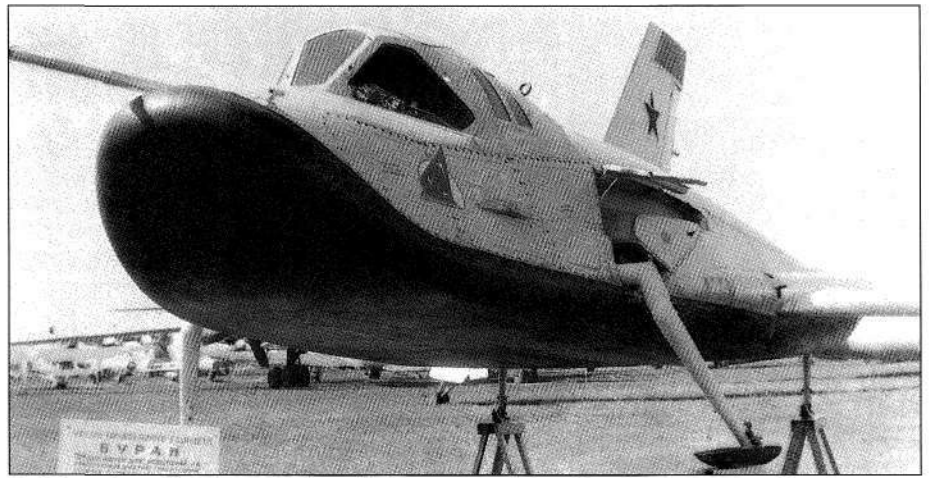
The Mikoyan space interceptor was unique in concept. Rather than using a launch-pad-based rocket to put the shuttle into orbit, the OKB-155 team opted for a launching scheme from the back of a hypersonic (capable of speeds greater than Mach 4) aircraft. The mini-shuttle's anticipated mission would be quite short - only three orbits - but of sufficient length to intercept, inspect, and if necessary, destroy targeted American satellites. The Mikoyan plan was the first time a two-stage (mother craft, and shuttle riding pick-a-back) reusable launch system was given serious consideration beyond the design stage. In late June 1966, the Kremlin sanctioned the concept.

There is confusion about exactly when *Spiral* began. Recent information indicates that Sergei Korolev was interested in the project and suggested that, instead of a hypersonic aircraft as the launcher, the R-7 rocket be used - and that the first mission could be achieved by the end of 1967. Even though most histories claim that the project began in 1966, it is obvious by Korolev's participation that Mikoyan's effort would have had to begin somewhat earlier.

The MiG *Spiral* engineering team was headed by Gleb Lozino-Lozinskiy, whose name would eventually be linked to several Russian shuttle projects in the intervening years. According to Lozinskiy's original plans, the development of a shuttle capable of subsonic flight was to begin in 1967 with the development of the hypersonic launching aircraft a year later. The full-scale uncrewed vehicle would have been orbited by rocket from the Baikonur Cosmodrome in 1970, with the first crewed mission launched from the back of the hypersonic aircraft slated for 1977. This ambitious schedule was destined to be derailed by political events.

The testing scheme for the *Spiral* shuttle craft was planned to be followed in three steps (to test thermal and stress effects on the orbiter's structure) in the subsonic, supersonic, and hypersonic speed regimes. Because the full-scale vehicle was to have seated two persons, sub-scale craft to be used were in 33% and 50% sized models.

In 1968 and 1969, the hypersonic version of *Spiral* was tested three times in suborbital tests. These were launched from the Plesetsk Cosmodrome (located near Archangel, near the Arctic circle) and the models were recovered at the Kapustin Yar missile testing facility near the Volga river delta, over 2000 km distant. The analogues were called BOR 1-3, an abbreviation for *Becpilotniye Orbitalniye Raketoplan* ("Unpiloted Orbital Rocket plane"). The first BOR test used a wooden model due to a materials shortage. The Russian engineers found that wood had sufficient ablative



Article 105.11 of Project Spiral on display at the Zhukovskiy Air Museum outside of Moscow. As can be seen, the landing gear employs the use of skis. GRIGORI OMELENKO



A back view of Article 105.11 of Project Spiral on display at the Zhukovskiy Air Museum outside of Moscow. This shows that the craft on display in Moscow was retired with its rocket engine in place. The wings can be seen to have hinges - thus changing their dihedral angle to test flight characteristics of different wing configurations. GRIGORI OMELENKO

qualities to enable a reentry control flight test to be successfully conducted. The model burned up at 60 km altitude, while it was telemetering its data to ground-tracking stations.

The second phase of the project - flying subsonic and supersonic analogues that would be piloted in the Earth's atmosphere - was suspended in 1969 (apparently the secret manned lunar landing project absorbed most of the roubles allocated for space projects). In a published interview Lozino-Lozinskiy commented that "the *Spiral* programme was dropped in 1969 because the Politburo felt it would take too much time and money to bring [the project] to completion. *Spiral* was resumed in 1972 under the support of Valentin Glushko [a premier designer of rocket engines - his engines have powered nearly all Soviet liquid-fuelled missiles and space launchers]."

Even though the project was resuscitated in 1972, *Spiral* was heavily modified. Gone was the aim of an orbital spacecraft mission, and the hypersonic mother craft (that was the responsibility of the Tupolev design bureau) was cancelled, due to insurmountable problems with constructing

suitable engines to power the aircraft. All that was left was the subsonic, piloted analogue labelled "Article 105.11". Between May 1976 and September 1978, eight crewed sorties took place, with both take-offs from runways and air-drops from transport craft as part of the mission manifest. Power plants that were tested included both jet and rocket engines, and special ski landing gear was evaluated as well. One Summer incident revealed by Russian archives describes a test that was not going well - Article 105.11 was unable to take off from a runway due to its skis sinking into the black-topped surface. Engineers rose to the challenge in a whimsical way - they smashed watermelons from a nearby farm collective over a 70 m stretch of runway and placed watermelon halves under the craft's skis. The novel lubricant allowed the scheduled flight test to take place.

Because its orbital mission was cancelled, the *Spiral* project was on its last legs. In late 1978, this MiG effort ceased to exist despite 75 million roubles (about \$113 million US dollars) invested in the project.

(Part 2 of this four-part series is due to appear in a forthcoming issue.)

Endeavour Launched on

STS-67 was the eighth flight of the orbiter Endeavour and the 68th of the Space Shuttle programme. The mission, with a planned length of 15 days, 13 hours and 32 minutes, was to be the longest one to date. Threats of weather complications dogged the early hours of the STS-67 launch countdown as managers kept a wary eye on approaching rain and high winds. However, the weather pattern moved faster than initially predicted and by the early hours of 2 March 1995 the skies over the Kennedy Space Center had cleared completely. Endeavour was successfully launched at 1:38:34 am in the morning.

The primary objective of the mission was to provide a platform for the ASTRO-2 ultraviolet astronomy payload. Accordingly the two Payload Specialists in the crew had been chosen for their knowledge of the science instruments and experimental objectives and were crew members of the first ASTRO mission which flew on STS-35 in December 1990.

ASTRO-2 was composed of three experiments and their support equipment. These were the Hopkins Ultraviolet Telescope which conducted spectroscopy at wavelengths of 830 to 1,860 ångström, the Ultraviolet Imaging Telescope which recorded film images of faint objects in the 1,200 to 3,200 ångström part of the spectrum and the Wisconsin Ultraviolet Photo-Polarimetry Experiment which obtained spectro-polarimetric and spectro-photometric observations of galactic and extra galactic objects at 1,400 to 3,200 ångström wavelength.

The mission also included as secondary experiments the Commercial Materials Dispersion Apparatus Minilab/Instrumentation, two protein crystal growth experiments, the Middeck Active Control Experiment and the Shuttle Amateur Radio Experiment. One Get Away Special experiment, in two canisters, was mounted on the payload bay wall. (For further details of the experimental payloads and the crew see *Spaceflight*, February 1995, p.64.)

Processing Endeavour for the STS-67 mission was delayed for ten days in October of 1994 as STS-68, the previous mission of Endeavour, landed in California at Edwards Air Force Base due to poor weather at the Florida landing facility. The modified Boeing



Above: Attending the simulated countdown at pad 39A on 14 February from left to right are: Mission Commander Stephen S. Oswald, Payload Specialists Ronald A. Parise and Samuel T. Durrance, Mission Specialist John M. Grunsfeld, Payload Commander Tamara E. Jernigan, Mission Specialist Wendy B. Lawrence, Pilot William G. Gregory and Back-up Payload Specialist Scott Vangen.

PETER GUALTIERI,
WEST KENTUCKY NEWS

Right: A basket for emergency escape from White Room level on pad 39A holds up to two crew members. It travels down the wire and is decelerated by a net which is attached to a cable and chain.



PETER GUALTIERI, WEST KENTUCKY NEWS

747 Shuttle transport aircraft returned Endeavour to the Kennedy Space Center and on 21 October the orbiter entered the Orbiter Processing Facility's work bay one.

Due to the planned length of time in orbit the orbiter was configured with the Extended Duration Orbiter (EDO) equipment. Designed and developed

by Rockwell's Space Systems Division, the EDO mission kit allows a Shuttle to remain in orbit up to 16 days, plus two days of contingency, compared to a nominal Shuttle mission of eight days plus contingency. Major elements of Rockwell's EDO unit include additional reactants for power generation by the orbiter's fuel cells, a regenerating system to remove carbon dioxide from the cabin atmosphere, an improved waste collection system, additional nitrogen for the cabin atmosphere, and the creation of more habitable volume and storage space in the crew cabin.

The 15 foot diameter EDO pallet which contains the additional fuel cell reactants is mounted in the aft end of the payload bay. It holds four sets of cryogenic hydrogen and oxygen tanks and control equipment, the tanks be-

Left: In an area of the VAB, the SSME's are checked, repaired and leak tested. A boost turbopump is dominantly to the fore in the picture and below it is the primary pump. The red collars around the large pipes cover corrugated sections which allow flexing of the pipes.

PETER GUALTIERI, WEST KENTUCKY NEWS



Longest Shuttle Mission

BY ROELOF SCHUILING
at the Kennedy Space Center

ing supplemental to Endeavour's own five liquid oxygen and hydrogen tanks. The 368 pounds of hydrogen at -418° F and 3,125 pounds of oxygen at -285° F provide enough electrical energy to run a four person household for six months. In addition, the power generation process provides approximately 3,500 pounds of pure drinking water for the crew as a by-product. The EDO pallet weighs about 7,000 pounds of which half is reactants and half tanks, structure, piping and distri-



Endeavour is seen just about to enter the VAB on 3 February 1995.
E. RUDOLF VAN BEEST

bution system. Installation of the pallet was completed on 21 November 1994.

On 14 December the ASTRO-2 payload was delivered to the orbiter and installed in the payload bay. Following connections with the orbiter, the payload bay doors were closed on 21 December in preparation for the end-of-year holidays. KSC prelaunch preparations are held in abeyance during this time and maintenance operations are performed with reduced personnel. Following the holidays, the payload bay doors were reopened on 3 January 1995. The ASTRO-2 interface test with the orbiter was run on 5-6 January.

Beginning on 19 December the orbiter's main engines for STS-67 were installed over the next several weeks with time out for the Christmas-New Year's Day holidays. Completion of the last engine installation and checkout was on 9 January 1995. In the number one, or upper, position was SSME #2012 which had five previous flights, 21 total starts and 6,158 seconds of firing time. SSME number two, in the lower left, was #2033 with six previous flights, including OV-105's last mission STS-68, 11 total starts and 3,993 seconds of firing time. SSME number three was #2031 with 11 flights, 17 total starts and 8,159 seconds of firing time.

The payload bay doors were closed on 20 January in preparation for the

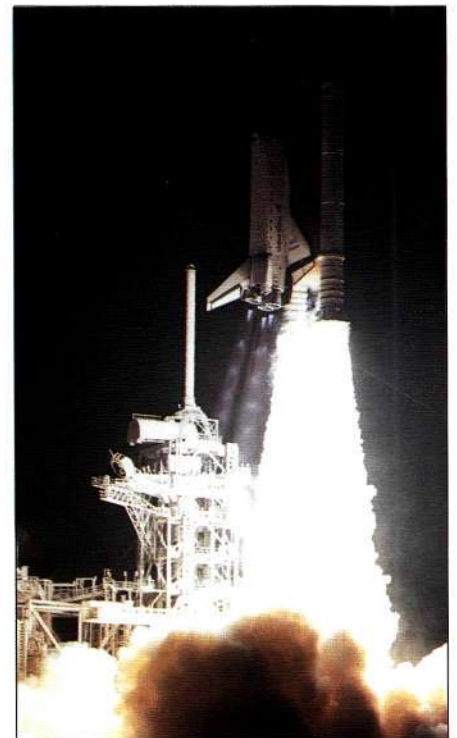
move from the Orbiter processing Facility to the Vehicle Assembly Building which occurred during the morning of 3 February. Following the mate of the orbiter to the External Tank and Solid Rocket Boosters on top of Mobile Launch Platform number One the connections were tested and preparations were made to move to Launch Complex 39A.

The move to the launch pad began at 7:44 am on 8 February. The Space Shuttle and its launch platform were hard-down on the pad at 2:05 pm the same day. On the following day, a hot fire test of Auxiliary Power Unit One was accomplished.

Launch pad operations for STS-67 followed the normal Shuttle profile. A simulated launch countdown, using the actual flight crew, was held on 14 and 15 February, and on 15 February the Flight Readiness Review was held. After assessing status and projected operations, managers confirmed 2 March as the launch date. The actual launch time was targeted at 1:37 am on that date. The night launch satisfied the ASTRO-2 science requirement of

Endeavour has just between rolled out through the open doors of the VAB on 8 February 1995. The Launch Control Complex can be seen on the left.

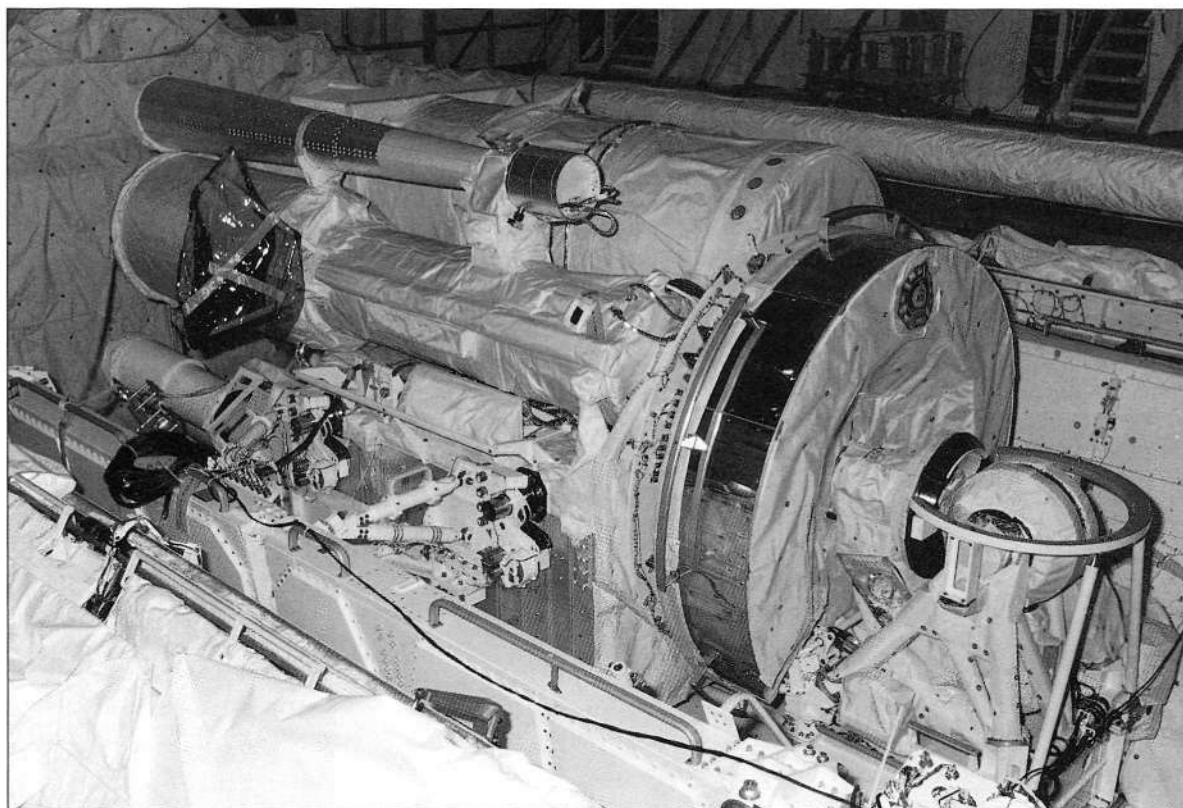
PETER GUALTIERI, WEST KENTUCKY NEWS



The jets of Endeavour's three LH₂/LOX main engines exhibit shock cones as the orbiter pushes upwards against the External Tank and the two giant boosters pull them both spacewards. It may be noted that the 'hammer-head' crane has been removed from the top of the tower on pad 39A, but not on pad 39B where it appears in a photo on p.150.

PETER GUALTIERI, WEST KENTUCKY NEWS

having orbital shadow while outside the South Atlantic anomaly for 95 per cent of the mission orbital operations. The opening of the launch window was dictated by sunrise at the possible trans-Atlantic abort sites. The operationally usable launch window lasted until 4:32 am based on sunset at End of Mission (EOM) times. However the limit of crew-on-back time to



In the Orbiter Processing Facility on 14 December 1994 when the ASTRO-2 payload was delivered to the orbiter and installed in the payload bay. NASA

2.5 hours after planned T-0 dictated an actual launch window closing at 4:07 am.

During the prelaunch operations a Mass Memory Unit failed and on 21 February it was replaced with a unit taken from the recently-landed Discovery orbiter.

Shuttle managers were assessing possible concerns with a Flash Evaporator System coolant loop which showed a slight leak. Assessment of the leak showed it was improving but the analysis delayed the ASTRO-2 closeout operations by one day to the 22nd. These operations included removal of instrument covers for flight and film installation. The payload bay doors were closed for flight on the 24th. At 10:15 on the 26th, the STS-67 crew members arrived at the KSC Shuttle Landing Facility airfield, having flown in from the Johnson Space Center.

At 2:00 am on 27 February the STS-67 launch countdown began with the countdown clock at T-43 hours. A series of seven built-in-holds during the countdown would add 28 hours and 37 minutes to the count. This would bring the planned T-0 to 1:37 am on the morning of 2 March 1995.

As the countdown began the weather picture for the 2nd did not look good. Forecasters were predicting only a 20 per cent chance of acceptable weather due to a cold front which was approaching the Kennedy Space Center.

The countdown proceeded normally however, back-up flight systems were checked, flight software was reviewed and loaded into the orbiter's comput-

ers, flight crew stowage was in progress, and the pyrotechnic initiator controllers were checked during the 27th. Later on that day the pad was cleared of personnel for the hazardous loading of the fuel cell reactant tanks and the EDO tanks with liquid oxygen and hydrogen.

The loading operation continued until about 10:00 am on the 28th. After the pad was reopened for normal personnel work the orbiter's mid-body umbilical was demated and retracted into the pad service structure. Launch vehicle and facility closeouts followed as did activation of Endeavour's communications systems and Inertial Measurement Units.

As the morning before the planned launch dawned, the weather picture still did not look good. However, as the day progressed it became apparent that the cold front was moving faster than originally predicted.

Meanwhile, on Launch Complex 39A, the Rotating Service Structure was moved back from Endeavour at 11:00 am on Wednesday 1 March. At Houston, the communications at Mission Control were being configured for the launch.

The Mission Management Team met, as usual, prior to the planned External Tank loading and the weather was improving sufficiently for them to give a "go" for main engine propellant loading. At about 5:17 pm the External Tank loading operation began.

Back at the Operations and Checkout Building the crew were awakened at 8:42 pm and Mission Commander Oswald, Pilot Gregory and Mission Specialist-Two Lawrence had

a weather briefing at 9:42 pm. The crew departed for Launch Complex 39A at about 10:22 pm and arrived at the White Room at about 10:52 pm. They boarded the orbiter and shortly after midnight the crew hatch was closed.

The countdown continued to go well and the weather had cleared sufficiently to meet the launch requirements by the final built-in-hold at T-9 minutes. The hold was extended by about one and a half minutes however, as a Flash Evaporator System heater was approaching a low temperature limit. The launch team brought up an alternate one and the countdown was continued with the plan of holding at T-5 minutes if the alternate one was not ready at that time. The additional hold was not required as the system was ready and the STS-67 countdown continued down to T-0 with no further concerns.

The STS-67 launch and ascent were normal. The Maximum Dynamic Pressure (MAX Q) was passed at 50 seconds after launch and the Solid Rocket Boosters shut down and separated at 2 minutes 5 seconds into the flight. Main engine cutoff came at 8 minutes 38 seconds into the mission followed by External Tank separation 12 seconds later. Endeavour was then 800 nautical miles downrange at a velocity of 16,700 miles per hour. The orbit was 28.45 degrees in inclination with a perigee of 33 nautical miles and an apogee of 185 nautical miles. The Orbital Manoeuvring System was fired and at the completion of the firing Endeavour was in its planned orbit of 190 by 188 nautical miles. ■

Returning to Mars

A major focus for NASA's programme of Solar System exploration is the planet Mars. The investigations of the Viking orbiters and two landers, launched in 1975, were to have been continued by Mars Observer, scheduled to go into orbit about the planet in the summer of 1993, but the spacecraft went silent near the time of orbit insertion about Mars and has not been heard from since then.

A series of launches is planned, with lift-offs from 1996 to 2005, at every Mars opportunity, to recover most of the science that Mars Observer was to have obtained and to extend those objectives. Emphasis has been placed upon low cost through the use of advanced technology and innovative design.

On August 1, 1994, Donna Shirley was appointed Mars Exploration Program Manager, reporting to the JPL Director, Dr. Edward Stone. I met with her to discuss her plans for Mars.

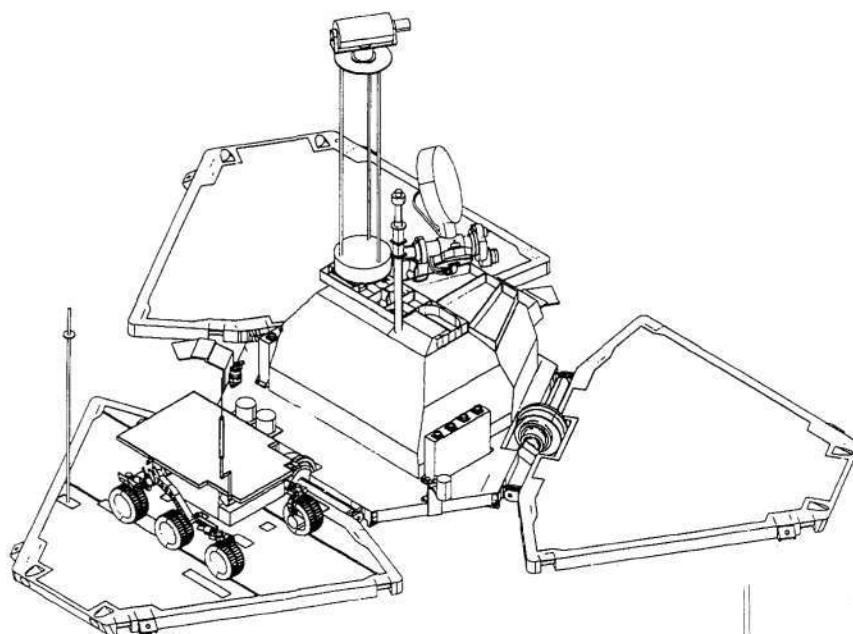
Mars completes one revolution about the Sun in approximately 687 Earth-length days. With Earth's period of revolution at just over 365 days, Mars and Earth will reproduce, more-or-less, their mutual geometric relationship in somewhat more than two Earth years. This fact is important because it is the genesis of the Mars launch opportunities mentioned above. If one had unlimited launch-vehicle capabilities, such opportunities would not be relevant, but to have minimum or near minimum trajectory options available, a favourable alignment of Earth and Mars is essential.

The current NASA exploration plan is built around these launch constraints for the next five opportunities: 1996, 1998, 2001, 2003, and 2005. At each opportunity, an orbiter and a lander will be sent to Mars, and the cost caps on these missions grow smaller with time. For the 1996 opportunity, the Mars Global Surveyor (MGS) will be launched in November of that year with arrival at the planet in September 1997. It will carry six of the eight Mars Observer instruments and study the planetary surface, from orbit, for a full Martian year.

For this JPL managed mission, the spacecraft is being built under system contract to Martin Marietta, Denver. The exact cause of the failure of the Mars Observer spacecraft could not be identified, but a list of probable causes has been assembled and corrective actions are being taken with respect to the MGS vehicle. For example, the propulsion system will be new.

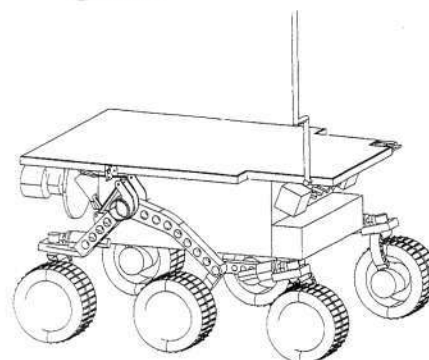
The reduced mass of MGS, with respect to Mars Observer - two large instruments were deleted - allows the use of a Delta 2 launch vehicle (Mars Observer used a larger vehicle, the Titan 3), and the overall cost of MGS is down by about a factor of six from Mars Observer.

In October 1994, the Magellan spacecraft, at the end of its highly successful exploration of Venus, was lowered into the Venusian atmosphere in a controlled experiment to provide test data for the old idea of using atmospheric braking for control of spacecraft trajectories. The information from Magellan experience will al-



Above: Mars Pathfinder is scheduled for launch in December 1996. NASA/JPL

Right: With a mass of only 10 kg, the rover of Mars Pathfinder is, nevertheless, a very capable machine. NASA/JPL



BY DR W.I. McLAUGHLIN
Pasadena, California

low MGS to brake, with confidence, from a large initial elliptical orbit about Mars to the smaller circular mapping orbit, without the expense of carrying along a large chemical propulsion system.

The second participant in the 1996 opportunity, a lander, is Mars Pathfinder. This project also has the distinction of being the first in NASA's Discovery series: low-cost (\$150M) missions designed to fly frequently, as in the early days of the Agency, and provide a steady flow of scientific information concerning the Solar System. Pathfinder is scheduled for launch in December 1996, a month later than MGS, but will arrive at Mars in July 1997, two months earlier than the orbiter. Unlike Viking (and unlike Apollo-to-the-Moon), Pathfinder will proceed directly from Earth to the landing

on Mars, without pausing, first, to go into Martian orbit. The flight system is being built at JPL.

Donna Shirley said that an innovative landing system was required to promote mission success and contain costs. A radar altimeter signals the proximity of the surface (as the lander is descending by parachute) and retro-rockets fire while air bags are deployed to surround the vehicle protectively. Once on the surface, the lander will be righted by selectively opening a tetrahedron of enveloping petals. (Precautions are also taken to insure that the cut parachute does not descend onto the lander.)

The lander itself will do three things once it is on the surface of Mars: serve as a weather station; record stereo, multispectral views of the nearby topography; and release a

small rover.

The rover, a 10 kg mighty mite which is dear to Donna Shirley's heart since she managed its development prior to her current assignment, constitutes a technology experiment. While the Mars Pathfinder project is being managed by NASA's Solar System Exploration Division, the rover is developed through its Office of Space Access and Technology.

The rover will investigate Martian soil mechanics by means of wheel-motion techniques and provide close-up views of rocks, such as might be obtained with a geologist's hand lens. In addition, it will carry an "alpha-proton-X-ray spectrometer" to place against rocks in order to determine their elemental composition.

The rover will be guided about the surface of Mars by an operator on Earth, using a computer-constructed "virtual environment" based on images obtained by the camera of the lander. An icon of the rover will be moved to the desired spot in the scene, and the rover commands to get from the rover's current location to the chosen spot will be generated automatically.

Donna Shirley characterized the rover as "the world's smartest spacecraft" but said it was desirable, though not absolutely necessary, to keep it in sight of the lander. Rover and lander communicate with one another via UHF and the lander talks to Earth over an X-band link. As befits an intelligent creature, the rover will rest during the Martian night, waiting for the return of the Sun and its energizing light; a peak usage of 16 watts is foreseen. The "smarts" of the rover are manifested through its capability to interact significantly with the environment. For example, if a wheel drops into a pit, this cautious creature will back up. The rover also has the ability to sense trouble in advance by the technique of spraying a pattern of laser light ahead of it and deducing the nature of the topography by noting distortions in the pattern. But the rover does not navigate by means of an elaborate world model within its computer; rather, it is equipped with a set of behavioural rules with which it reacts to the challenge of the moment. (See the August 1988 edition of this column for details of the "subsumption architecture" of MIT researcher Rod Brooks, the architecture upon which the rover of Mars Pathfinder is based.) The prime mission of Mars Pathfinder is short: 30 days of operation on the surface.

The 1998 Mars opportunity will, as mentioned above, also feature an orbiter and lander and slated to provide the two launches is the Med Lite launch vehicle (about one-half of a Delta), which is being developed to NASA specifications. The orbiter will probably fly one of the two remaining instruments from Mars Observer's payload (both would be too heavy),

Space Archives

Space activity, worldwide, has been underway long enough for the subject of space to have acquired a significant history. On the other hand, this accumulation of events is sufficiently modest that individual historical collections can contribute to a degree not possible in more developed fields. The JPL Archives, established in April 1989, extends to the early days of the Laboratory and includes a diversity of material within its scope.

The afternoon I spent at the facility served as a personal introduction to the Archives and yielded some insights.

The Archives is located a few miles east of the principal site of JPL, at the Laboratory's Foothill Complex (Building 512, 145 North Altadena Drive, Pasadena). There are 3000 square feet of storage, and the physical preservation of the materials is aided by monitoring with hygrothermographs.

Researchers planning a visit should advise the Archives of their intended areas of research, in advance, so that the suitability of the collection can be assessed. In addition to printed records and still photographs, the Archives has collections in motion picture film, videotape, and CD-ROM formats. Researchers can obtain further information by writing (Archives, MS 512-110, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109) or telephoning

(818-397-7674).

My delving into the Archives was guided by no articulable principles of research; I functioned more as an amateur geologist inspecting strata at various epochs and gawking at the marvel of it all.

If the geological metaphor were pursued, it would have to be pre-Cambrian time that was represented by events before the start of JPL *per se* in 1944. In looking at an organizational chart from May 1943, two things stood out. First, Frank Malina (1912-1981), one of the founders of JPL, was not at the top of the chart. He was in "second place", as "Chief Engineer", under the noted aerodynamicist, Dr. Theodor von Kármán (1881-1963). Second, the title of the organization was "Air Corps Jet Propulsion Research Project, California Institute of Technology, GALCIT Project No. 1". "GALCIT" stands for Guggenheim Aeronautical Laboratory,

California Institute of Technology engineers with the pilot of the first JATO test flights in August 1941. Left to right: Clark Millikan, Martin Summerfield, von Kármán, Frank Malina and Homer A. Boushey, the pilot.



and the lander's tasks include a search for volatiles, e.g., where did all the water go?

Donna Shirley's challenge is to develop the 1998 missions with one half the budget and about half the launch mass that have been allocated for the 1996 duo (and the 1996 set is, in equivalent dollars, one tenth the cost of Viking).

The Mars programme has an international flavour. For the 1998 set, there is an option to undertake "Mars together" with a Russian Proton launcher, and with an increased international payload (with respect to the US-only options). "Mars together"

would recapture all of the Mars Observer science plus flying a French balloon and a Russian rover. In addition, the 2003 opportunity could feature collaboration with ESA: an "InterMarsnet" programme of multiple small landers.

From the nadir of the failure of the Mars Observer spacecraft, a promising programme has been quickly put together under tight budget constraints. This response fits well with tradition; for the last century the Red Planet has seemed to act as a powerful lure for explorers and writers, who approach it in a manner that can be only described as relentless. ■

California Institute of Technology, and was headed by von Kármán. (In 1936, GALCIT rocket experiments had begun in the Arroyo Seco, near the present site of JPL. See *JPL and the American Space Program* by Clayton Koppes, reviewed in the April 1983 edition of this column, for some history.)

Attesting to the primeval status of this stratum, I was unable to recognize the names of any of the 78 people listed on the chart (aside from von Kármán, Malina, and Clark Millikan (1903-1966), son of Nobel Laureate physicist Robert Andrews Millikan, who was President of Caltech from 1921 to 1945). I came to JPL in 1971 and thought that my name-recognition apparatus would have detected some who were employees in 1943; the time span is not unreasonably long, but the number of people is so small.

The chart is separated into four "sections" below the top echelon of von Kármán, *et al.* of which two are "Liquid Propellant" and "Solid Propellant", as befits the Laboratory's mission at this time. (Today, little work is done in propulsion at JPL.) There is a subsection labelled "computing", which, of course, would have had a very different flavour from a similarly named group today. Looking back, one can appreciate the heft of logarithmic and trigonometric tables; the analog artistry needed for efficient operation of a slide rule; exotic automata such as the cylindrical calculator of Edwin Thacher.

A letter in the Archives from Jack Parsons, who headed ("Chief Engineer") the Solid Propellant Section, to Frank Malina was dated May 5, 1942 and written on the stationery of the Hotel Governor Clinton ("1200 rooms with bath, servitor, radio, circulating ice water"). The subject of the correspondence was the test of a rocket motor which Parsons had witnessed in order to learn if the device would be of any value to programmes of the proto-JPL. "The valve stuck and ben-

The first successful interplanetary mission was that of Mariner 2 to Venus in 1962. The event was celebrated with a floral float in the annual Tournament of Roses parade in Pasadena, California in January 1963. Dr William Pickering, then Director of JPL, was Grand Marshall of the parade. NASA/JPL



The first US Earth satellite, Explorer I (1958), was not only scientifically successful but attracted considerable public attention. (JPL is operated by the California Institute of Technology, "Caltech", for NASA.) NASA/JPL

zene, fire, etc. raised hell in general. There was no great damage but that was the end of the test". The letter includes a sketch of the apparatus.

After the second World War, JPL developed, in the environment of the Cold War, a series of rockets for the US Army. The orbiting of the Soviet Union's Sputnik I in October 1957 was answered in January 1958 by the Explorer I satellite (see the February 1983 edition of this column for some reminiscences on the twenty-fifth anniversary of the occasion), but the implications for civil space of the Soviet achievement were not restricted to Earth orbit. The Archives contains a note dated October 25, 1957 from the then JPL Director William Pickering - he led the Laboratory from 1953 to 1976 - outlining the elements of a programme for the scientific exploration of the Moon. The communication, directed to Lee Dubridge, then President of Caltech, states: "The recent USSR satellite success implies that Russia *now* has the capability of conducting flights to the Moon carrying scientific instruments. National interest appears to require the United States to demonstrate as soon as possible that US science likewise has this ca-

pability".

When space science was very young, the logic of Cold-War policy helped it to grow, as this document, one of myriad examples worldwide, shows. Today, economic competitiveness, through technology development, and public education are important as policy factors with regard to mission selection, but scientific values are dominant in the peer review of proposals. The success of endeavours such as the Voyager exploration of the outer planets and the Hubble Space Telescope's astrophysical researches have established the merits of the case for science.

Lunar, planetary, and other space ambitions did come to fruition in the next few years, but the legacy of the Explorer series was deemed important. Project Manager Jack Froelich wrote (July 7, 1958), "I hope that the major contribution of the Explorer to Space Technology is prudence in choosing design objectives". And again, "The engineering philosophy behind Explorer programs was to demonstrate simplicity and experience in order to minimize cost and time of development, and to obtain the greatest possible reliability". ■

Reusable Ideas

Ideas constitute a multitudinous tribe since they span a large part of human experience. The set of aspects of ideas is not as large, but it is certainly not inconsequential. Thus, ideas can be important, atomic, vague, subtle, innate, related to one another by association, or have an historical route of development. As an example of the last attribute, the idea of space travel has an ancient pedigree and is still evolving. A concept that has intrigued me for a long time is that of a reusable idea.

The definition of "idea" is not, I believe, easy to come by, and my trip to the dictionary is not worth reporting. Therefore, for now, I have not the temerity to try to define "reusable idea". An example will serve. For me, the quintessential reusable idea would be (note the subjunctive) an application of

chess to an entirely different field than the game itself. Think of how powerful the extensively developed strategy and tactics of this intellectual edifice could be if turned loose in a fresh arena! Find the right mapping from the game to the world and you could be a king (or a queen if you really wanted

power).

To be more specific, I am referring to the reuse of the "syntax" (formalism, rules of operation) of an idea while switching its semantics (meaning, object of reference) to a new topic. Beware a popular use of "semantics" which nearly reverses the above employment of the word and refers to inessential variations in the manner of expressing an idea. I employ "semantics" to denote meaning because this use permits an informative contrast with "syntax".

Reusable ideas, in a less dramatic sense, are everywhere. Algorithms are designed to handle repetitive situations that only differ in limited and prescribed ways. Principles, rules of thumb and other distillations of experience fall in the category as, without too much of a stretch, do words themselves. But such regions of the reusability concept are of little interest for the present purpose. Let us turn to a few more cogent examples, from space.

In the May 1989 edition of this column, I took some axioms of historian Frederick Jackson Turner's "frontier theory" and mapped them, with little modification except for a change of place, from the American West to those regions above the atmosphere we call "space". (Anticlimactically, I am unable to report success, or failure, for the experiment since I contented myself with merely repainting Turner's structure and did not follow up with elaboration or a quest for evidence that these axioms might be applicable to space.)

The May 1983 *Spaceflight* contains another of my rather grandiose speculations wherein I have listed candidates for the five all-time best ideas for astronautics:

- (1) staging of rockets (Simienowics, 1650),
- (2) radio tracking (Huelsmeyer, 1904: patent for navigational use on the Rhine River),
- (3) gravity assist (murky pedigree: del Rey 1939 is one point),
- (4) synchronous orbit for communications satellites (Clarke, 1945), and
- (5) the decision to go to the Moon (Kennedy, 1961).

Although I have not traced the historical connection, if any, between (2) and our present practices, it qualifies at least *prima facie* as a reused idea.

So, reusable ideas may not be tremendously rare, but, in some measure, they probably are uncommon. For, "reusable idea", as I employ the term, must present an element of surprise, and we are not habitually in the startled state.

Of course, surprise is relative to what you know. The so-called electromechanical analogy in physics relates the behaviour of materially dissimilar

systems, e.g., a certain electrical circuit emulates the dynamics of a pendulum. However, a glance at the differential equation which governs both systems reveals the basis for the analogy and surprise vanishes.

In addition to surprise, a second attribute which I propose for the reusability concept is complexity. Although simple ideas can be brilliant and fall into the reusable category, I still have my eye on the possibilities presented by chess and would require, for my definition, complexity in the idea to be recycled. Thus, sticking in the vein of games, the alternative employment of chess or checkers would qualify but not tick-tack-toe. Complexity *per se* is not what I am after but rather the anticipation that the idea to be reused will be a reservoir of many virtues, a cornucopia.

The third and last property I propose to accompany surprise and complexity (or richness) is that the idea to be utilized not be a mathematical theory. It seems a bit strange to impose a negative stricture, but the domain of applied mathematics is so large and effective that it would obscure our present enterprise through domination. In fact, Eugene Wigner wrote (1959) a paper with the title "The Unreasonable Effectiveness of Mathematics in the Natural Sciences", testifying to the continuing puzzle as to how the gift from the Greeks of symbolic formalism can time and again foreshadow physical discovery.

Although I have shied away from defining "idea" - I doubt if a useful verbal formula is achievable - some seventeenth century philosophers such as John Locke (1632-1704) thought that we look inward in a manner similar to (external) perception to gain knowledge of our ideas. The phrase "I see it!" applied to understanding an idea attests to the popularity of this metaphor. (I have found Ian Hacking's 1975 book *Why Does Language Matter to Philosophy?* a clear exposition of the history and relationships of "ideas", "words", "meaning" and the like.) In response to the question as to whether chess, frontier theory, or any other complex construct should be labeled an "idea", some justification for the usage can be obtained by postulating the viewing of an intricate, internal ideascap.

Two motives have impelled me to produce the above sketch of a small portion of the realm of ideas. First, and trivially, for a long time I have had this itch about the potential reusability of chess, and now I have, if not scratched it, possibly created a few other sufferers. Second, I believe that there are certain storehouses of existing ideas which may well prove amenable to reinterpretation in the context of space.

On the principles that one might be most likely to profit by quarrying disciplines that are replete with formalism

and remote (relative to the intended reuse) in subject matter, the vast edifice of scholastic philosophy, as developed in the Middle Ages by Thomas Aquinas (1224/5-1274) and others, would be a prime candidate. Medieval philosophy with its reliance on logic and grammar satisfies the selection criterion of possessing significant formalism. In suggesting reuse, I make no judgment concerning the traditional semantic content of the subject.

An obvious application of medieval studies would be to the theory of extraterrestrial life, and, indeed, the relationship of speculating on intelligent life in the universe to methods of theology has not gone unnoticed. However, I am suggesting a search for more radical uses of the forms of scholastic philosophy, uses that are semantically further removed than extraterrestrial intelligence. One suggestion is to inspect the theological theory of the trinity for its relevance to systems analysis. Augustine of Hippo (354-430), who predated the scholastics and lived in the last years of classical antiquity, wrote *De Trinitate* and the subject flourished for the next thousand years. The reason I think there may be a link to the interests of systems analysis is that the concept of the trinity, which is difficult and not at all easy to state, reaches for principles of organization which differ from our common definitions of "system". Renewed interest in nonlinear systems and concurrent engineering reflects the recognition that something beyond the traditional approaches is needed. (Note that I have used "systems analysis" in ways that apply to both physical systems and engineering systems, i.e., concatenations of things and people.)

Incidentally, and off the main track of this essay, the trinitarian concept, if an attempt were made to translate it to symbolic form, might bring fresh ideas to logic and that branch of mathematics known as set theory. Although mathematics might appear to be unfettered in choosing its foundations, there are indications that it could be tied to specific structural features of human neural organization (see the recent book, *Realism in Mathematics* by Penelope Maddy), and, hence, new departures would be appropriate and valuable.

There is a long list that can be compiled for objects which have a well developed syntax. Items might include: poems and musical pieces; chemical reactions (Whoops! As described in the November 12, 1994, *Science News* the subject has been borrowed for reuse by a computer scientist.); Sanskrit grammar; codes of law; rules of parliamentary procedure; systems of etiquette; principles of organization of colonies of social insects. And if you need even more challenge, contemplate reusing three-dimensional chess. ■

Max Valier, 1895 - 1930

This year marks the 100th anniversary of Max Valier's birth (in February 1895) and this month sees the 65th anniversary of his tragic death (on 17 May 1930). The German rocket pioneer not only left behind a lot of unfulfilled potential - he played a major role in firing Germany's passion for the rocket and laying the ground work for the space age.

Born in Bozun on 9 February 1895 to a family descended from the French Huguenot nobility, Max Valier developed a deep interest in astronomy at a young age. By 1915, when he was drafted into the German Army, he had already begun the study of physics, astronomy and mathematics in Innsbruck.

Lt. Valier immediately applied his scientific interest to aviation, as he flew as a test observer on new aircraft. A crash landing in 1918 made him aware of the need for reliable and efficient airplane power plants.

It was *The Rocket in Interplanetary Space*, the book by Hermann Oberth, that galvanised Valier's creative thinking. He read the book in 1924. The war was over and Valier was pursuing his study of astronomy. The short leap between astronomy and space travel was quickly accomplished; Valier became dedicated to the idea of interplanetary travel and confident that the rocket was its key.

Valier pursued the dream, spending two years searching in vain for a wealthy sponsor. What he needed, he finally concluded, was something more concrete than a mere idea. He needed hardware - in this case a rocket-powered airplane - to convince potential backers.

Oberth, however, was not so keen on the idea. When Valier sought his advice, the pioneering rocket scientist

The cover of Max Valier's *Raketenfahrt* (Verlag R. Oldenbourg, Munich 1930) drawn by Hans von Rommer.



BY HENRY MATTHEWS

Beirut, Lebanon

was worried that the public might be put off by the poor performance of the rockets - then only in the early stages of development. Why would the public support a project that depended on a type of engine with a thrust barely greater than conventional motors and clearly less reliable?

But Valier was convinced that a stratospheric rocket-powered airplane would drum up financial interest in building a spaceship.

Things finally started to move in 1928 when auto industry tycoon Fritz von Opel agreed to finance Valier's rocket research. This cooperation led to several rocket-car experiments and the first rocket-powered airplane, the Ente, which was flown on 11 June 1928.

But the Valier-von Opel cooperation was short-lived. Valier felt that von Opel used the rocket research to fuel his own publicity machine. Valier split with von Opel, and began working with J.F. Eisfeld, a manufacturer of powder rockets. They built several rocket powered cars and a rocket powered sled that was demonstrated at a local sports competition.

Von Opel's own rocket flight on 29 September 1929 earned him unprecedented acclaim in the press, which confirmed Valier's opinion of the tycoon's intentions.

During this period Valier investigated alternative engines and developed a steam-powered booster that would provide a car with extra speed, without exposing it to the dangers of rocket propulsion.

Valier also produced RATO units which were successfully tested on a heavily loaded Junkers seaplane (Ju W33) in summer 1929. Weighing 3 tons and thus unable to take off on its own single reciprocating engine alone, the plane used a battery of Valier's powder rockets to make two successful rocket-assisted take-off tests at Dessau and Leopoldshafen on 30 July and 9 August. The flights lasted 12 minutes and 17 minutes respectively and were made by Junkers Chief Test Pilot Wilhelm Zimmermann and an observer named Shinzinger. But by this time Valier was convinced that only the liquid-fuelled rocket engine clearly out-performed all existing airplane powerplants. This led to a partnership with Dr Paul Heylandt at the end of



Max Valier.

1929. Heylandt, who was a liquid hydrogen manufacturer contracted Valier to produce a liquid-fuelled rocket engine, offering him 6,000 DM. With Valier were his assistants Walter Riedel and Arthur Rudolf.

Development of the new engine proceeded successfully. The first ignition took place on 23 January 1930. On 17 and 18 April, Valier drove his RAK-7 car, equipped with this liquid-fuel engine, in a breath-taking demonstration.

Seeking financial support from Shell Petroleum, he set about building an airplane to cross the English channel that would be equipped with this engine, using Shell oil paraffin. Valier was confident that when his engine was perfected, it would fly a rocket airplane from Berlin to New York in two hours.

This engine was never perfected. During bench trials on 17 May 1930 at Berlin Airfield, it blew up. Steel shrapnel hit Valier in the neck and chest and he died on the way to the hospital, the first researcher killed in a liquid-fuel rocket accident. A sad, but premature end to a glorious and promising existence. ■

Valier and the VfR

Max Valier was one of the most enthusiastic members of the German Society for Space Travel (Verein für Raumshiffahrt - VfR), which was founded on the evening of 5 June 1927 in the German industrial city of Breslau, a city now within the boundaries of Poland. But Valier's rocket experiments were severely criticised by the other VfR members, because they felt that he was side-tracking public attention from the liquid-fuelled rockets that they dreamed of building someday, particularly that he began by using solid-propellant rockets, and for ground-vehicle propulsion.

Tragically, Valier died during research work with a liquid-fuelled rocket engine that the VfR considered of great value.



Early Space Policy: Project Orbiter

Sir, In his article "New Revelations About the American Satellite Program Before Sputnik", Dwayne A. Day states: "It is not clear from where the original question of having the Army involved in satellite launches originated." [1].

In fact, the initiative for the Explorer launcher (Juno 1) came from the Office of Naval Research (ONR) in Washington, see "Prelude to the Space Age" [2]. In this Alexander Satin, former Chief Engineer, Air Branch, ONR, acknowledged the influence of early BIS studies carried out between 1948-1951 for "minimum satellite launchers" [3].

Cdr Ted Wilbur provided further background to the project which became known as "Orbiter" [4] pointing out that Cdr George Hoover, a much respected US Navy pilot and engineer, played a major role alongside Satin.

Cdr Wilbur explained that "Frederick C. Durant arranged the first meeting at ONR between Hoover, Dr Wernher von Braun and other scientists to discuss the possibilities of a satellite project [5]. Further meetings established the feasibility of the programme and contracts were let."

However, "when a subsequent proposal by the Naval Research Laboratory (NRL) was given precedence by the Department of Defense, Orbiter fell by the sidelines and Vanguard took over. When there was no successful launch prior to the Soviet Sputnik, in an effort to catch up in the race for space, Dr von Braun and his team were asked for an urgent assist.

"On relatively short notice, in January 1958, a face-saving orbit was achieved by Explorer I. It was essentially a modification of Orbiter. Because of the work previously done by Hoover and the others, it was a fairly simple matter. It could have been accomplished months earlier."

Alexander Satin acknowledged the BIS contribution in a letter dated 23 November 1977. He wrote (in part):

"Gentlemen: I have been planning for some time to write to you concerning your excellent paper, "Minimum Satellites Vehicles", in the book *The Artificial Satellite*, London 1951 - Proceedings of the Second International Congress on Astronautics.

"May I inform you that this paper was used by me during 1952/54 to direct the first United States Space Project at the Office of Naval Research in Washington DC, where I was Chief Engineer of the Air Branch, to an immediate application with available hardware in the United States. "I saw Mr A.C. Clarke on November 25, 1952 at his home - 88 Nightingale Road, Bounds Green, London. Mr Clarke told me of your report, which I obtained the following day. When I analysed your data I immediately saw that we could make a three-stage rocket with a very small orbiting payload, using hardware available to us at the Office of Naval Research. This

eventually became our ONR Project Orbiter and was launched as Explorer I in January 1958."

KENNETH W. GATLAND
Ewell, Epsom, UK

References

1. *Spaceflight*, 36, 11, November 1994, pp.372-373.
2. *Spaceflight*, 24, 11, November 1982, pp.386-392.
3. K.W. Gatland, A.M. Kunesch and A.E. Dixon, "Minimum Satellite Vehicles", *JBIS*, 10, 6, November 1951, pp.287-294; also *The Artificial Satellite*, Proceedings of the 2nd IAF Congress.
4. Cdr Ted Wilbur, "Let George Do It...", *Naval Aviation News*, December 1971, pp.9-19.
5. Erik Bergaust, *Reaching for the Stars*, Chapter 24.

The author replies: Kenneth Gatland's comments regarding my article "New Revelations About the American Satellite Program Before Sputnik" (November 1994) are essentially correct. However, he misunderstood my comment about the origins of getting the Army involved in satellite launches. I was referring to who asked the question that led to the evaluation of the Jupiter C for launching a satellite in late 1956 or early 1957, NOT the origins of what became the first American satellite, Explorer 1. The Army's satellite proposal, known as Project Orbiter, had already been rejected for the IGY Scientific Satellite Program at the time this question was asked. At some point in the summer of 1956, someone in either the White House or the Pentagon asked if the Jupiter, often mistakenly referred to as the Redstone, could be used to place a satellite in orbit earlier than the Vanguard. Who this person was and why he asked the question at that point still remains a mystery. As the newly declassified documents I mentioned in my article demonstrate, this proposal was rejected at that time for various reasons. Considering the growing consensus that the Scientific Satellite Program was a "stalking horse" for the military reconnaissance satellite programme, this is an important question.

Gatland, however, simplifies the situation by implying that BIS studies of satellites directly influenced the design of Project Orbiter. He quotes Alexander Satin, who was then Chief Engineer of the Air Branch of the Office of Naval Research, who says that the BIS study proved to him that it was feasible. But the origins of the idea were earlier and the actual decision to build the satellite has a more unusual genesis.

In a spring 1950 meeting at James Van Allen's home, the prospect of an International Geophysical Year had been discussed. S. Fred Singer, a physicist at the University of Maryland, had proposed building a satellite for the IGY. Singer later proposed a Minimum Orbital Unmanned Satellite of the Earth (MOUSE) at the fourth Congress of the International Astronautics Federation in Zurich, Switzerland, in the summer of 1953. Singer's paper was based upon a study prepared two years earlier by members of the BIS. Singer's paper refined the earlier calculations and proved that a satellite was possible.

On 23 June 1954, Frederick C. Durant III, former president of the American Rocket Society and then current president of the International Astronautical Federation, called Wernher von Braun at the Redstone

Arsenal and invited him to a meeting two days later in Washington, DC at the Office of Naval Research. At this meeting, plans were discussed for developing a satellite programme using already existing rocket components. Further meetings followed at which the Army gave tentative approval, provided that the cost was not too great and the plan did not interfere with the missile development. Von Braun's secret report, *A Minimum Satellite Vehicle: Based on Components available from missile developments of the Army Ordnance Corps*, was submitted to the Army in September and summarised what he had said at earlier meetings. This proposal became the Army's candidate for the IGY satellite project, Project Orbiter, which was later abandoned in favour of Project Vanguard, proposed by the Naval Research Laboratory.

Von Braun thus found himself locked out of the IGY Scientific Satellite Program. His excessive enthusiasm and optimism for space flight, and the publicity it had garnered, did not sit well with those actually running the programme. In addition, Eisenhower's desire to separate the satellite programme as far as possible from ballistic missile development also had an influence on excluding the Army from participation.

But even though von Braun and the Army were officially precluded from developing a satellite, von Braun and his rocket team lacked faith in the Navy's Vanguard Project and secretly worked on their own satellite plans. In late 1956, after the Vanguard Project was well under way and after the Army had once again been denied a chance to launch a satellite, one of von Braun's closest associates, Ernst Stuhlinger, made contact with James Van Allen. Van Allen was one of the leaders in planning initial science missions to be conducted in space. Stuhlinger informed Van Allen that, although von Braun had been ordered not to place a satellite in orbit with the Jupiter C, the team had grave doubts about the officially sanctioned Vanguard Project. Stuhlinger discussed possible scientific payloads capable of being carried atop a Jupiter C. On 23 November 1956, he sent a letter to Van Allen thanking him for the meeting and proposing that Van Allen visit the Army Ballistic Missile Agency to view their operations, which he apparently did [1]. Van Allen responded on 13 February 1957 with a list of possible scientific payloads [2]. This second letter was sent to William Pickering, Director of the Jet Propulsion Laboratory of the California Institute of Technology. JPL was then also part of the Army. It was JPL who built the Explorer I satellite. When the first American attempt to launch a satellite atop Vanguard ended in public embarrassment, von Braun's team was given the go-ahead to attempt a launch. They already had a satellite well underway, despite the fact that they had been specifically ordered not to work on space projects. Their clandestine and forbidden contacts with Van Allen were what allowed the United States to respond so quickly with Explorer I.

References

1. Ernst Stuhlinger, Director, Research Projects Office, Development Opns Division, Army Ballistic Missile Agency, US Army Ordnance Corps, to Dr Van Allen, Department of Physics, Iowa State University, 23 November 1956, University of Iowa Library, Special Collections.
2. J.A. Van Allen, Head, Department of Physics, State University of Iowa, to Dr Ernst Stuhlinger, Army Ballistic Missile Agency, 13 February 1957, University of Iowa Library, Special Collections.

Walter Hohmann

Sir, I would like to draw your attention to a piece of space history: 115 years ago, on 18 March 1880, the German technician and city architect of Essen-on-the-Ruhr, Dr Walter Hohmann, was born at Hardheim, Germany. His book "Die Erreichbarkeit der Himmelskörper" (The Attainability of the Celestial Bodies, 1925) dealt with the problems of conservation of energy in departure trajectories from Earth, return to Earth, and transfer orbits to other planets (see Kenneth Gatland's *The Illustrated Encyclopaedia of Space Technology*, 2nd edition). In the 1910s and 1920s he was first to develop the idea to use a ferry craft "Beiboot" to land on the Moon after separation from a spaceship (i.e. a lunar module). To honour his work a crater inside Mare Orientale on the Moon's far side has been named "Hohmann". He died 50 years ago on 11 March 1945 at Essen.

UWE ZELTWANGER
Ingersheim, Germany

Deceased Cosmonauts

Sir, With regard to Mr Ward's comments to Vadim Molchanov's letter (*Spaceflight*, March 1995, p.95) I would like to add the following:

Indeed, it seems certain that Grigory Nelyubov committed suicide. But there is no proof that it was not an accident, since he reportedly was very drunk at the time he was hit by the train. Therefore, it may very well be that it was an accidental death after all and it is, in my opinion, correct that Mr Molchanov lists his death as a railway accident.

Vasily Shcheglov died on 19 July 1973. The date in Doug Hawthorne's book was proved to be incorrect several years ago. When trying to find out the correct date (which had only been listed as 1972 at the time that his name was first revealed) I saw on the headstone of his grave that even the year was incorrect: it was 1973. Further research in the files at Zvezdny Gorodok resulted in the correct date.

The headstone of Vladislav Gulyayev's grave gives 31 May 1938 as the date of birth and 19 April 1990 as the date he died.

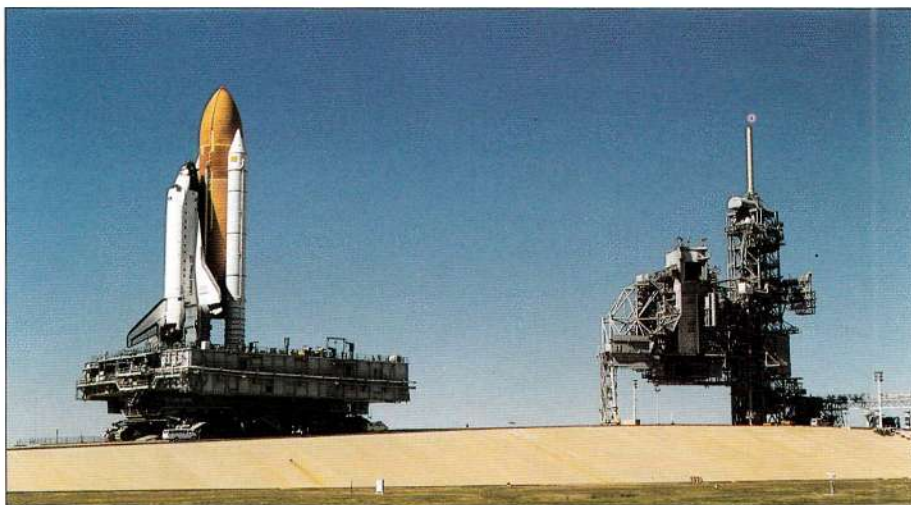
The headstone of Aleksandr Petrusenko's grave gives 1 January 1942 as the date of birth.

I hope these correct dates will be of use to people who want to get their files correct.

BERT VIS
The Netherlands

Right: Just a few hours after the launch of Discovery on 3 February 1995, the space shuttle Endeavour is 'rolled over' from the Orbiter Processing Facility (OPF) to the Vehicle Assembly Building (VAB) in which it is attached to the External Tank and the two SRB's. In this photo, Endeavour rolls from the light of the OPF into the darkness of the night.

E. RUDOLF VAN BEEST



KSC Visit

Sir, Recently I again visited the Kennedy Space Center. Beside the launch and landing of the STS-63/Discovery, I saw many other very interesting things. I had the opportunity to look around in the OPF, VAB and O&C Building, I was present at the roll-over and roll-out of the Space Shuttle Endeavour and saw the tower rollback and launch of the Atlas-2/UFO. I hope the enclosed pictures will give you an impression of some of the things I saw.

E. RUDOLF VAN BEEST
The Netherlands

Above: Endeavour moves slowly up the ramp to launch pad 39A on 8 February 1995. One end of the crawler is raised higher than the other in order that Endeavour stays vertical during the climb.

E. RUDOLF VAN BEEST

Below: It is February 1995 and work is already in hand in the Operations and Checkout (O&C) Building for STS-73 due for launch in September 1995. Teledyne Brown employees are working on the USML-2.

E. RUDOLF VAN BEEST



New Korolev Booklet

Sir, I list what I see as new material or items put into a new perspective by a recently published booklet on the Soviet missile and space programme [1]:

1. The first German V-2 was launched on 18 October 1947. The first launch of the R-1, a "native" version of that missile, was on 17 September 1948, but it had a control system failure. The first successful flight of the R-1 was on 10 October.
2. The R-5 missile was first launched on 15 March 1953. It had a range of 1200 km and used alcohol and LOX. Its take-off thrust was 43.8 tons. As the R-5M, it was modified to carry a nuclear warhead and first launched on 21 January 1955. It was launched with a live nuclear warhead on 2 February 1956 and went into service that year. Geophysical variants called R-5A (1958-1961), R-5B, R-5V (1964-1975, including Vertical flights) and R-5R were also developed.
3. The R-11 missile using nitric acid and a 'carbon hydrogen fuel' in an Isayev built engine was created in 1953. It had a range of 270 km. Its thrust was about 8 tons and its warhead weighed 670 kg. Its first launch was on 18 April 1953 and it became operational in 1955. The R-11M variant was designed for a nuclear warhead and its first launch was on 30 December 1955; it became operational in 1958. The R-11FM variant was designed for submarine launch: it was first launched from a 'swinging sea stand' in May 1955. It was launched from a surfaced submarine on 16 September 1955 and from a submerged submarine on 23 December 1958.
4. Interplanetary Spacecraft: The Zond-1 (also designated "3MV-1 No. 4") drawing (on page 48) has a clearly-labelled "descent apparatus". Zond-2 (also designated "3MV-4 No. 2") has in its place a "special section", as does Mars-1 (also designated "2MV-4 No. 4"), where it is parenthetically also described as "camera". Photographs show Venera-1 ("1VA", or "1VA No. 2" on page 126), Venera-2 ("3MV-4 No. 4") and Venera-3 ("3MV-3 No. 1"). The text (on page 10) describes the October 1960 Mars failure vehicle as "1M". Zond-3 is designated "3MV-4 No. 3". Later probes came from the Babakin bureau.
5. The dogs aboard all the Vostok precursor flights are also named: 28 July 1960: Chaika and Lisichka; 19 August 1960: Belka and Strelka; 1 December 1960: Pchelka and Mushka; 22 December 1960: Shutka and Kometa; 9 March 1961: Chernushka; 25 March 1961: Zvezdochka.
6. Details are given on the Zenit spy satellite programme. The first flight vehicle was designated "Zenit-2". Its first launch on 11 November 1961 failed but another was launched successfully on 26 April 1962. The Zenit-4 began flying later and in 1964 the work on such spacecraft was transferred to the bureau headed by D.I. Kozlov.
7. The R-9 two-stage military missile was developed in 1961. It weighed 81 tons, had a 2 ton payload and a range of 12,500 km. Its first launch was on 9 April 1961 and it became operational in 1964. A variant called R-9A, but not otherwise described, was also built.
8. Solid-fuel missiles were also first developed by the Korolev team. The RT-1 was first launched on 28 April 1962 and was called a "strategic" missile but range and operational dates were not given. The RT-2 was called the first "solid-fuel ICBM" and its first launch was on 26 February 1966 with entry into service in 1968.
9. A photograph shows the GR-1 three-stage "global" rocket which was capable of reaching any point on

Earth from any direction, on parade. It is not mentioned anywhere in the text.

10. The N1 rocket was conceived in the early 1960s with variants called N11 (second, third and fourth stages only) for a 20 ton payload, and N111 (third stage with new upper stage) for a 5 ton payload.
11. In discussions of the lunar programme, the Kosmos-379, 398 and 434 vehicles are acknowledged as T2K vehicles, but Kosmos-382 (and its reported November 1969 launch failure analogue) are not (on page 16).
12. A photograph of the Salyut-1 vehicle on the launch pad shows the name "Zarya" painted on the side, and describes how "Salyut" was the name later given to the press. A photo of the next Korolev Salyut, which became "Kosmos-557", is shown with "Salyut-2" painted on the side (on page 87).
13. The high-quality photographs of Energiya-1 show the payload plainly painted "Polyus" (also referred to as "Skif-DM" in the text), and one pad view seems also to have the initial letters of the name "Mir" (or "Mir-2"?) painted around its waist.

I have deliberately sought to avoid interpretation so that my colleagues in the BIS can pursue their own thinking without extraneous influence. Later the significance of this material for the history of the Sergey Korolev rocket and space team can be discussed at length. I am continuing to assess the cornucopia of new information and photographs in this wonderful booklet.

JAMES OBERG
Texas, USA

Reference

1. G.A. Kustova (ed.), "From First Satellite to Energiya-Buran and Mir", Space Corporation Energiya, 1994.

Trip to Baikonur

Sir, When you only stand 900 m from a launch pad, the rocket looks like it is going directly overhead before it pitches over. And there is plenty of dazzling flame and crackling roar - standard stuff, but never boring. I was the first and so far only visitor at Baikonur to wave an American flag and get away with it.

I went with a commercial tour group, Cosmos Tours, and despite their past chequered reputation, they did everything right this time. About twenty of us were housed right on the cosmodrome, in a clean, comfortable hotel right between the cosmodrome museum and the house used by Sergey Korolev. It was within walking distance of the vehicle assembly building, the rail lines from Leninsk, a number of old sheds made from N-1 moon rocket adaptors, other key cosmodrome facilities, and the desolate open steppe. We went everywhere and were told merely to keep our cameras inside our jackets when not using them, so as not to attract undue attention.

We stayed a full extra day after the press and the VIPs had rushed off and had plenty of time to see a long list of facilities and a good tour of the city of Leninsk beyond the reach of the security guards. There was time to see, and time to sit outside and feel, the conditions there, and time to meet the human beings who must work there.

My trip was paid for by IEEE Spectrum and I will be producing a 5000 word assessment for them of the future of Russian space technology for publication in the fall. Of course, Baikonur's future is crucial to the US, as well as to the future of the International Space Station. The tour was a good opportunity to enter through doors opened for the other tourists, but also it allowed me to take side trips to visit Russian space experts and personalities.

We toured the Energiya NPO Museum in Kaliningrad (the city sign still has the big red hammer and sickle symbol) and there was my book *Red Star in Orbit* in a glass case on display. Shoved over in the corner of the main display hall was a

spacecraft I had never heard of before, with a mission and 1960s flight history absolutely unfamiliar to me - there are still surprises to be wrung out by curious eyes and pressing questions.

My Russian tongue was very nearly good enough for all challenges, and this was quite encouraging. I was not entirely sure what challenges (and threats) the visit would entail as I had been told by Russians that their mafia is angry at my mentioning the rich villas being built by some space officials. But I completed the trip unshot, unrobbed, unpoisoned and unharmed in general - with a whole load of new observations that I am now digesting.

As I get my pictures, slides, and souvenirs organized, I will try to figure out more. But it was a fabulous trip, wildly successful, in no small part thanks to the support of friends in Moscow, and especially at home from Cooky, Greg, and John. Now to capture as much as possible in writing...

JAMES OBERG
Texas, USA

Apollo Look-Back

Sir, In a letter in the February issue of *Spaceflight*, E.T. Pugh addresses the issue of whether it was John F. Kennedy or Lyndon Johnson who decided that the National Aeronautics and Space Council should be saved.

Pugh cites Charles Murray and Catherine Bly Cox's excellent book *Apollo: The Race to the Moon*, and John Logsdon's seminal *The Decision to go to the Moon* to bolster his argument that it was Johnson who convinced President-elect Kennedy on 20 December 1960 to save the NASC and make the Vice President chairman of the Council. Murray and Cox cite Logsdon. Logsdon in turn states that Kennedy aide Ted Sorensen was initially in favour of eliminating the Council, but "By the time of Kennedy's December 20 meeting with Johnson, this decision had been reversed. Kennedy had decided that he wished to assign to Johnson responsibility for the space program." (p.67). Logsdon cites consultation with Willis B. Shapley for this information. Logsdon's book makes clear that the decision to retain the NASC had been made *before* the 20 December meeting. The question is why? Who swayed Kennedy? Was it Johnson?

As I stated previously, historian Giles Alston in 1993 provided John Logsdon and myself with a copy of a memo he obtained from Richard Neustadt, who in December 1960 was a consultant to Kennedy's transition team. The memo was dated 20 December 1960 (the date of the meeting between Kennedy and Johnson). The memo stated that there was an "opportunity" to revitalise the NASC with the Vice President as Chairman. It appears as if this memo merely stated what Kennedy and Neustadt had concluded: that Johnson should be given a prominent role in directing the nation's space programme. Given Johnson's high visibility on this issue during Sputnik, this was a logical conclusion.

There is, however, a slight problem: the cover letter for the memorandum is dated 23 December 1960. But it is written as if done on the same day Kennedy was scheduled to meet with Johnson. The cover letter reads in its entirety:

"Attached is the memo you asked me to prepare and send you in time for your meeting with Senator Johnson. You wanted something you could give him to work on and worry about. I hope this meets the purpose. It is a 'quickie', worked up today in collaboration with Budget staff and no doubt could be vastly improved. But the main thing was to get you something to use. Here it is"

signed: Richard E. Neustadt
(underlining in original) [1].

The different date on the cover letter is confusing, but Logsdon and I jointly concluded that it was a mistake probably made in the haste to which Neustadt referred. Neustadt's later extensive involvement in the reformulation of the NASC indicates that he was probably the one to convince Kennedy that it was worthwhile, not Johnson.



STS-63: the photo was taken at Darmstadt, Germany 22 minutes after lift-off at 5:44 UT on 3 February and shows the bright trail of Discovery. The bright spot in the lower part of the picture is the planet Mars. Photographic details: 2.8/16 mm Fisheye; 19 s exposure; ECTACHROME 400 Panther.

GERHARD HOLTkamp

Rendezvous Shuttle Watch

Sir, The advent of Shuttle/Mir rendezvous flights offers new opportunities of shuttle watching for European observers. Having seen the live coverage of the launch of STS-63 on CNN at 5:22 UT on 3 February 1995, I went to a window of my flat in Darmstadt, Germany. As expected, Discovery exited Earth shadow at 5:44 UT, 22 minutes after lift-off and appeared as a bright object high in the west-southwest. Less than a degree below Discovery and moving in tandem with it was a distinctly rust-coloured object: the External Tank which just 13 minutes earlier had separated from the orbiter and which in half an hour or so would burn up over the Indian Ocean. The relative brightness and colour of Discovery and its External Tank were comparable to the planets Venus and Mars respectively and made a very impressive sight indeed. Reaching for my binoculars I was rewarded with yet another treat as the orbiter and the External Tank were surrounded by more than half a dozen small fuzzy white dots. (Clouds of spent fuel or water ice? Any better ideas?).

The ascent trajectory of Mir rendezvous flights (and in later years flights to the International Space Station) will lead the shuttle over Southwest England, Northern

France, Southwest Germany, Austria and the Balkan states between 20 and 26 minutes after lift-off. If launch occurs during the first two hours after (European) sunset or during the two hours before sunrise (allow for a larger margin during the summer) observers in Europe will be able to see the shuttle and its External Tank move from the west or northwest toward the southeast during that time. The closer you are to the groundtrack the higher in the sky they will peak (in the southwest or the northeast depending on which side of the track you are on). As the launch window for such rendezvous flights is only 5 minutes, you do not have to wait for more than that beyond the 20 to 26 minutes after the scheduled lift-off time. If you do not see it by then, the launch might have been scrubbed, the shuttle might have stayed in Earth shadow during the pass, the sky might have been too bright or it could have been too cloudy.

The enclosed picture shows a 19 seconds exposure of the above mentioned pass of STS-63 Discovery as seen from Darmstadt, Germany, 22 minutes after lift-off at 5:44 UT.

GERHARD HOLTkamp
Darmstadt, Germany

One possible response might be "so what?" What does it matter? Probably little.

I agree with most of the other points made by Mr Pugh in his letter, including the importance of Johnson to Kennedy politically and on Johnson's hidden agenda to use the space programme to funnel money to the South. But it is around such apparently minor disputes that space historians have become entangled. There are distinct Eisenhower, Kennedy and Johnson historical "camps" which attempt to claim credit for different ideas for each respective man. There are those who claim that NASA's organisational structure was Johnson's idea, others who ascribe this to Eisenhower. There are even more obscure disputes about

the NASC than that detailed above. These are usually argued by those who were in some way connected to the events in question, and it highlights the importance of seeking an objective outsider to write the history, rather than a friend or close personal aide of the president, with his own agenda to meet.

DWAYNE A. DAY
Space Policy Institute
Washington DC

Reference

1. Richard E. Neustadt, Memorandum for Senator Kennedy, "Memo on Space Problems for you to use with Lyndon Johnson", 23 December 1960, with attached: R.E.N., "Problems of Space Programs", 20 December 1960.

Plesetsk "Dual" Launchings

Two launches were conducted from the Plesetsk Cosmodrome in Northern Russia on 22 March 1995.

The first, at 0409 GMT, was a Kosmos 3M carrier rocket and the second, at 1643 GMT, a Soyuz-U. The latter was claimed to be the 2660th launch since the inauguration of the Space Age.

Both rockets lofted Kosmos satellites for the Russian Ministry of Defence. The lighter Kosmos 3M booster lofted a small Kosmos 2310 navsat whilst the Soyuz orbits larger Earth observations craft. Fifty military and Air Force foreign attachés watched the day's events as a part of a fact-finding mission.

The last such "dual" launchings occurred during a 24-hour period on 1 to 2 April 1993 with the same booster combination as the 22 March launches. The launches came almost 15 years to the day since the worst accident at Plesetsk on 18 March 1980 and since that day no Plesetsk launch has been scheduled for 18 March.

NEVILLE KIDGER FEES FROM ITAR-TASS DATA

Ariane Resumes Service

After the failure experienced with Flight 70 on 2 December 1994, Arianespace was 'back in business' on 29 March 1995, when Flight 71 successfully placed two satellites into orbit: the Brasilsat B2 telecommunications satellite for EMBRATEL of Brazil, and Hot Bird 1, the first direct television broadcast satellite of the European organisation EUTELSAT. The launch vehicle was an Ariane 44 LP, the version with two solid and two liquid propellant strap-on boosters. The next launch, Flight 72, is scheduled for the third week of April 1995, when an Ariane 40 launch vehicle will be used to launch ESA's ERS-2 remote sensing spacecraft into sun-synchronous orbit.

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SPACELINE

Space Records Tumble at Mir Station

Mir Comings and Goings by Neville Kidger

The record-breaking space flight of Dr Valeri Polyakov ended at 0404 GMT on 22 March 1995 with the soft-landing of the Soyuz TM-20 descent cabin in a snow-covered steppe some 55 km North-East of Arkalyk in Kazakhstan.

Polyakov was launched into space with cosmonauts Viktor Afanasyev and Yuri Usachev on 8 January 1994 as part of the 15th main expedition to the Mir complex (EO-15). He returned with the crew members of EO-17, cosmonauts Aleksandr Viktorenko and Yelena Kondakova.

During his 14 and a half month stay in space he conducted a series of repetitive medical and biological experiments mainly upon himself to characterise adaptation to weightlessness.

Doctor Polyakov has smashed all space flight endurance records with his just-ended 438 day stay in space. This is in addition to 241 days in space in 1988-89 when he was sent to Mir to check upon the health of the first men to spend a whole year weightless, Vladimir Titov and Musa Manarov.

Manarov made a second extended flight on the complex to amass a total of 541 days in space, the previous record.

Yelena Kondakova also set a new record - 170 days - for the flight of a female cosmonaut. Viktorenko was making his fourth stay on Mir.

The cosmonauts leave in space the EO-18 crew of Vladimir Dezhurov, Gennadi Strekalov and American medical doctor Norman Thagard who will return with the other two following the docking of the Shuttle orbiter Atlantis. The EO-18 crew (called Mir-18 by the Americans) were launched on 14 March 1995 and docked with Mir two days later to begin an era in which the human space programmes of the USA and Russia are to merge.

There will be a review of the flight of the EO-18 crew in a forthcoming issue of *Spaceflight*.

Thagard's Mir Checklist by James Oberg

Prior to his launch on Soyuz TM-21 on 14 March Norman Thagard had made four shuttle missions totalling 25:04:44 of flight experience. His new launch set a world high of 13 people in orbit simultaneously. Coincidentally, the last record (12) was also set during an ASTRO mission. Furthermore, of the current 13, two Americans (Parise and Durrance) and one Russian (Viktorenko) were also part of that record space population. The following duration records will now be falling one after another. Doubtless there are numerous other numerical significances yet to be worked out. The flight is going to be a statistical treasure trove.

Event	Duration	Date Reached
Most experienced US shuttle astronaut (beats Musgrave)	10:13:26	March 24 at 19:37
Longest US flight since Skylab (beats STS-67)	16:15:08	March 30 at 21:19
Exceeds shortest Skylab flight (1973)	28:00:50	April 11 at 07:01
Surpasses longest Mir "foreign researcher" flight (Merbold)	30:12:36	April 13 at 18:47
Exceeds longest career total Russian guest cosmonaut (Chretien)	32:15:58	April 15 at 22:09
Exceeds Merbold STS/Mir total (only Russians are longer)	48:21:38	May 02 at 03:49
Becomes most experienced career US spaceman (world rank 38)	58:20:32	May 12 at 02:43
Exceeds middle Skylab flight	59:11:09	May 12 at 17:20
Achieves career total of 100 days (first US to do so)	74:19:16	May 28 at 01:27
Exceeds longest US mission (SL-4, 1974)	84:01:16	June 06 at 07:27
Set new US record (old plus 10%)	92:10:53	June 14 at 17:04

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-71	10 June	Atlantis	9+1 Days	Mir-01 Mission	51.6
STS-70	22 June	Discovery	8 Days	TDRS-G	28.5
STS-69	20 July	Endeavour	10 Days	WSF-2, Spartan 201-03	28.5
STS-73	21 September	Columbia	16 Days	USML-02	28.5
STS-74	26 October	Atlantis	6 Days	Second Mir docking	51.6
STS-72	30 November	Endeavour	9 Days	Retrieval of SFU (Japan launch), Spartan/OAST free flyer	28.5

ESA Astronaut Selected for EuroMir 95

Mission of 135 Days with Five-Hour EVA

During a press conference at the European Astronauts Centre in Cologne on 17 March 1995, the selection of the crews for the EuroMir 95 mission was announced. Thomas Reiter (Germany) was selected as member of the prime crew and Christer Fuglesang (Sweden) as member of the back-up crew.

Thomas Reiter will fly with cosmonauts Yuri Gidzenko, a test pilot and parachute instructor who was the standby flight commander for the EuroMir 94 mission, and Sergei Avdeev, physician who spent 189 days in space on board the Soyuz TM-15 spacecraft and Mir station as flight engineer and was the standby flight engineer for the EuroMir 94 mission.

The back-up crew consists of the very experienced commander Gennadi Manakov (two space flights to Mir on Soyuz TM-10 and TM-16 with 311 days in space), flight engineer Pavel Vinogradov and ESA-astronaut Christer Fuglesang. Noteworthy with respect to the back-up crew is the unexpected replacement of Sergei Treshev by Vinogradov who from 1977 to 1983 was working on the development of software for interactive computer systems for the design of reusable spacecraft and on the development of computational models concerning the aerodynamics and structure of spacecraft. From 1983 he worked in the lead design team for the Energiya launcher and on the development of computerised cosmonaut training systems. In May 1992 he joined the Energiya cosmonaut corps and since October 1992 has trained at the Yuri Gagarin Cosmonauts Training Centre.

Currently the launch of the EuroMir 95 Soyuz TM-22 is scheduled for 22 August 1995. The mission will last 135 days and that means the longest mission ever flown by a non-Russian astronaut.

One of the highlights of the mission is a five-hour space walk (EVA) by the European astronaut outside Mir in late September to install material samples in a European experiment mounted to the exterior of the Spektr module, which is scheduled for launch in late May. The samples will be exposed to the harsh environment of space to test the hardiness of materials used in spacecraft construction. During the mission, there will be a docking by the US space shuttle Atlantis in late October and the astronaut's return to Earth is planned for 4 January 1996.

Reiter and Fuglesang have been training for the mission since August 1993 at the Yuri Gagarin Cosmonauts Training Centre and also at ESA's Astronauts Centre (EAC). Training has been intensive because, for the first time, an ESA astronaut will be responsible for some Mir and Soyuz systems. Perhaps one of the greatest challenges during training was to overcome the language barrier. Both men are now fluent in Russian.

A busy scientific programme is planned for EuroMir 95. In total there are 41 experiments: 18 life sciences investigations, 5 astrophysics experiments, 8 material science experiments and 10 technology experiments. About 450 hours of the mis-



The EuroMir 95 prime crew inspect a model of Mir at the European Astronauts Centre, Cologne on 17 March 1995. Left to right: Yuri Gidzenko, Sergei Avdeev and Thomas Reiter.

E.R. VAN BEEST



Left: The back-up crew at the ESA press conference. Left to right: Christer Fuglesang, Gennadi Manakov and Pavel Vinogradov.

E.R. VAN BEEST

Below: Thomas Reiter in training with a Russian EVA suit at the Yuri Gagarin Cosmonaut Training Centre.

ESA (Supplied courtesy Rolf H. Schoevaart)

sion are allocated for scientific research. Roughly four and a half hours a day will be spent on the experiments. The rest of each day will be spent exercising and carrying out routine maintenance and other housekeeping duties. Like on Earth, no work is scheduled for the weekends.

EuroMir 95 will use more European equipment than the first mission, which mainly relied on hardware already aboard the station. About 350 kg of this equipment will be delivered to the station in July aboard an unmanned Progress cargo craft. Further equipment and samples will be launched aboard a Progress in September. The astronaut will only carry a very small amount of equipment when he is launched. European equipment will include a device for measuring the density of bones. Bone thickness reduction is one of the major physiological problems faced by astronauts on long duration flights and the research may also help the study of bone disorders on Earth such as osteoporosis. ■

*Material contributed for this item by
E. Rudolf van Beest and Rolf H.
Schoevaart is gratefully acknowledged.*





Environmental Monitoring from Space

Part 2 - Data and Applications

In Part 1 we looked at the basic technology of remote sensing by satellites and its current forms (*Spaceflight*, January 1995, p.23). We now outline the very wide range of practical applications to which it is put.

Data Supply

A Remote Sensing (RS) satellite transmits a stream of digital data (telemetry) to a receiving station on Earth. The tiny currents from the sensors described in Part 1 are converted into radio signals by means of which each scene is recorded as a series of numbers on magnetic tape. Such data are ideally suited to manipulation by computer and the images generated can be viewed on a special display screen. "Hard" copies may be produced by photographing the screen or by an ink-jet plotter or a laser film-writer connected to the computer.

The chief benefit of the use of digitised data is that they may be further processed by computer. The "raw" data must be corrected by reference to the calibration readings of the system. The basic corrections made are:

- Radiometric, which allow for different illuminations of a scene;
- Geometric, which allow for different viewing angles, the Earth's rotation and the orientation of the spacecraft.

Computer programs allow enhancement and clarification of the images, especially to bring out features relevant to the particular application required of the data. In addition, extra information can be obtained from the raw data by scientific analysis and the inclusion of airborne and ground data. Other information may be added, such as the imposition of maps and the high-lighting of such features as roads, parish boundaries, water courses, contours etc. It is at this stage that false colours are commonly added to represent different ranges of reflected intensities of microwave, infrared or visible radiation.

It is clear that reception and processing of data from Earth RS satellites requires a lot of sophisticated and expensive equipment and human expertise. These are not to be found in schools, nor in the majority of commercial and higher academic user in-

BY DR D.J. BELSON

Senior Lecturer
Faculty of Science,
The Nottingham Trent University

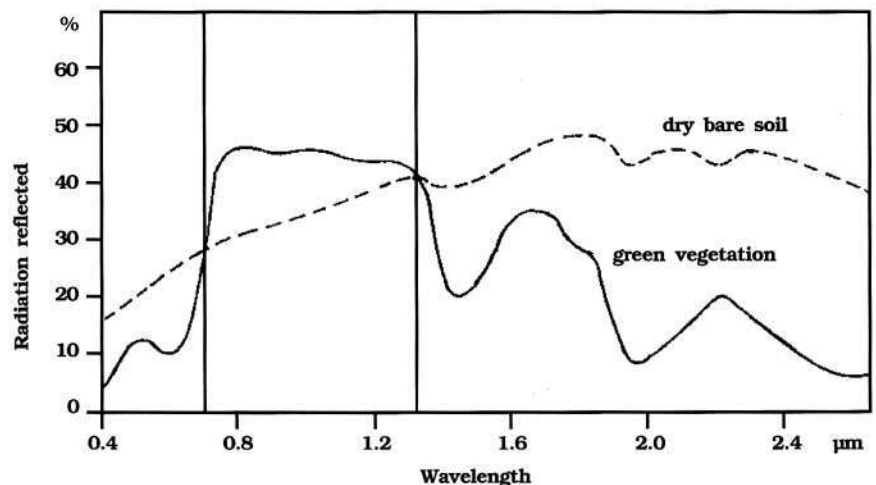
stitutions. Some large users can process raw data for themselves, but most rely on commercial firms which have been set up to process and distribute Earth RS data, such as the National Remote Sensing Centre Ltd.

Data on a required area of the Earth is supplied either as photographic image products (as described above) or in digital form, generally on Computer Compatible Tapes, but also on Exabyte Cartridges and optical, laser or floppy discs. This processed digital data can be interpreted for the application required by computer equipment normally available in schools and commercial firms. Currently operational RS satellites cover the whole globe and each scene typically shows an area of the surface of several thousand square km. For instance, a single Landsat scene shows a 185 km square, while a SPOT scene shows a 60 km square.

Applications

So to return to the problem posed

Typical spectra of reflected radiation.



Thematic information, extracted from a SPOT image map, shows clearing of primary tropical forest for farming and stock rearing in Para province, Brazil, 22 July 1989.

SPOT IMAGE/GEOSYS

at the beginning of Part 1, how does Remote Sensing from space help to monitor the destruction of the Amazonian rain forest? Well, for a start, any fires burning at the time when the scene is imaged show up brightly by emission of thermal infrared radiation; and the smoke may also be detected. Incidentally, oil-well fires in Kuwait and their associated smoke-plumes resulting from the Gulf War were monitored in this way. More importantly, the spectra of infrared wavelengths reflected by tree leaves and by bare soil are different and allow forested and de-forested areas to be visualised and the respective areas to be measured. In 1989, the World Bank estimated that 12% of Amazonia had been deforested. Subsequently, a study of satellite imagery showed that the proportion at that time was only 5%. Remote Sensing from space is able to provide reliable and accurate information about the environment. Without such information public pronouncements are of little value and the inter-relationships between natural and human processes in the environment are impossible to understand.

The applications of RS to monitoring of the environment are many and various. They are principally in the fields

of:

- Agriculture and Forestry;
- Geography, Cartography, Geology and Earth Resources;
- Land Use and Development;
- Pollution Detection and Monitoring;
- Atmospheric Physics and Chemistry;
- Oceanography.

The distribution agents for the SPOT system estimate that major uses of their images are:

Mapping	30%
Vegetation studies, forestry and agriculture	20%
Geology	18%

Only a few specific examples can be given here by way of illustration.

Agriculture and Forestry

Different infrared reflecting properties can be used to identify different plant species and to determine their state of health. Leaf indices, total biomass and water-content of vegetation can be measured. In this country, areas of young and old stands of heather on National Park moorlands, and the amount of bracken infestation, can be regularly mapped and measured from satellite RS images. Application to mapping and classifying of woodlands has also been demonstrated. Elsewhere, gypsy moth damage in hardwood forests and coconut plantations affected by blight have been detected and monitored. The nature and extent of agricultural yields and patterns of yields of different crops are routinely surveyed in many parts of the world.

Geology

Images are used to study topography and surface geology. They are the main source of information for modern geographical map-making and the large area covered by a single image makes it possible for geologists to make out lineaments, faults, dykes and shear zones and also to locate mineral resources, including oil. Erosion, sedimentation, hydrology and climatology can all be studied. The laying-down of oolitic limestone off the Bahamas has been visualised and rates at which deserts have extended in area have been followed. Movements in sand-dune fields can be monitored. Experiments with advanced microwave devices on Space Shuttle Orbiters have demonstrated their ability not only to see through cloud cover but to penetrate deeper into vegetation canopies and surface soils. It was this ability that permitted the detection of subsurface drainage patterns in the Sahara desert, i.e. buried vestiges of the rivers and streams that drained this area when it was still fertile, before climate change brought drought and erosion. The possible link between the effect of snow-melting on the Himalayan rivers and flooding of low-lying coastal areas is being investigated by an Indian RS satellite.



Sarajevo Airport with nearby residential tower blocks, buildings and minor roads. This image was acquired from an altitude of 270 km by the Russian Resource F-1 satellite's KFA-1000 camera system in 1991. Objects over 5 m in size are visible.

© NRSC 1993/DATA JEBCO/PRIRODA

Land Use and Development

Changing land-use patterns can be ascertained by regular monitoring of land surface processes, allowing management of resources. Man-made artifacts are surprisingly easily detectable, even when smaller than the resolution of the image, probably because of their high reflectivity and regularity of shape. It is like being able to detect otherwise invisible specks of tinsel or glass on the floor when they reflect light. For that matter, all stars would be too small and distant to be seen from Earth if they did not emit so much light. Thus, bridges, railways, roads and power lines can often be picked out. RS images are used in the planning and operation of off-shore industry and the location of sites for hydro-electric schemes and their environmental impact. Monitoring of deforestation has already been mentioned; the extent and rate of cultivation of range-land (natural grasslands used by grazing animals, both domesticated and wild) are also measured. RS is a useful tool in town planning; the extent and rate of urban expansion can clearly be followed. Specific problems like heat loss from poorly-insulated buildings can be surveyed.

Pollution

Aerial, marine and land pollution have all been studied from space. Shuttle astronauts have found that they and their photographs from orbit can detect and predict the paths of oil slicks on the sea. Individual tankers bilging their tanks can be tracked. It

has proved possible to monitor the hazards of waste disposal sites by checking water quality and stress on vegetation. Cooling water effluent from nuclear power stations can be tracked by measuring temperature differences. This allows "thermal pollution" to be minimised by selecting suitable locations for water inlets and outfalls and also the siting of any additional power stations nearby. An American satellite monitored thermal changes at Chernobyl, before and after the accident, in this way.

Atmospheric Properties

Vertical temperature and water vapour profiles of the atmosphere are regularly monitored, principally by meteorological satellites. The periodic ozone "hole" over Antarctica (depletion of O_3 in the so-called ozone layer of the atmosphere at certain times of the year) was discovered by an instrument carried by a meteorological satellite. Since then, the phenomenon has been further investigated by experiments from manned spacecraft in low Earth orbit, culminating in the launch in September 1991 of the unmanned Upper Atmosphere Research Satellite (UARS). In low Earth orbit, UARS carries instruments to measure infrared spectra of atmospheric gases, both absorption (of solar radiation) and emission. As well as ozone, these include gases like methane, carbon dioxide, water and compounds of nitrogen and chlorine thought to be involved in the processes of creation and destruction of ozone. The flux of

solar ultraviolet radiation responsible for starting these photochemical reactions, and the winds which continuously stir the gases are being monitored. In this way, ozone levels over the whole globe can be continuously checked and direct evidence obtained to increase understanding of atmospheric photochemistry. Concentrations of other gases, like carbon monoxide and other pollutants, have also been mapped by RS techniques.

Oceanography

Earth-orbiting satellites can just as easily give continuous surveillance of the vast expanses of the oceans as they can the land, which cannot be claimed by any Earth-bound method. Monitoring of sea-surface temperature and brightness is expected to lead to the location of plankton-rich regions and of fish stocks, essential information if resources are to be managed. Marine pollution can also be detected in this way. Sea-ice and icebergs can be located and followed, giving information obviously important to shipping, oil-rigs etc. ERS-1 also measures surface wind-fields, wave heights and ocean currents and thus can provide forecasts of sea state.

Further Information and Availability of Data

The National Remote Sensing Centre is the focal point for information and data concerning Earth RS. They are agents for products from Landsat, SPOT, ERS etc. A wide range of free booklets, leaflets etc. concerning environmental RS and its applications is available and general interest products such as posters may be purchased. Computer Compatible Tapes cost in the region of £1000 and single photographic products may cost from £20 up to around £500, but teaching packs for schools containing images and discs are available at very reasonable prices. There is an Educational Products Unit producing materials to meet the needs of the National Curriculum. The Education Officer makes school visits and visits to NRSC and seminars are arranged.

National Remote Sensing Centre, Delta House, Southwood Crescent, Southwood, Farnborough, Hampshire GU14 0NL.

EROS Data Centre is the distribution agent for Space Shuttle hand-held photography. They will provide ordering assistance and price lists.

EROS Data Centre, User Services Section, Sioux Falls, South Dakota 57198, USA.

National Council for Educational Technology provide information on the general uses of satellites in education. They have produced an information booklet, "Satellites in Schools", in conjunction with BNSC.

National Council for Educational Technology, 3 Devonshire Street, London W1N 2BA.

British National Space Centre advises the Government on space developments and opportunities and enacts their poli-



Satellite image of central London from Buckingham Palace to Trafalgar Square. NPA

Russian Data's Super-High Resolution

The Government of Russia has declassified and made available satellite imagery with a resolution of 2 to 5 m and, for the first time, satellite imagery is commercially available with a resolution comparable with that of high altitude aerial photography.

The Russian archival data bank is extensive and almost all of the images have been acquired since early 1989. Currently, images from territories of all parts of the world except Russia are available. Several new missions are launched each year and it is possible to request imaging of specific areas.

Nigel Press Associates (NPA) of Edenbridge, Kent are specialists in satellite mapping and are distributors of the Russian imagery from Priroda, which is the primary non-military remote sensing acquisition and processing organisation in Russia.

The National Remote Sensing Centre Limited (NRSC) is a distributor of high resolution digital Russian satellite imagery through an agreement with JEBCO Information Services Limited which is a company with offices in Houston, London and Moscow. JEBCO maintains and markets a large library of technical information related to oil and gas production within the CIS and has been active in the release of geological, geophysical and cartographic information from Russia and other CIS republics since 1989. The agreement gives NRSC access to current imagery and over two million separate photographic images, acquired during the past 19 years.

Priroda operates two satellites on a routine basis, Resource F-1 and F-2. Over the last 19 years, Priroda has av-

eraged three to four separate flight missions per year. Each mission has a total operational flight time of approximately 30 days, and a maximum period of photographic activity of approximately 17 days.

Photographic imagery is obtained over all areas of the globe with a maximum latitude of 82.3 degrees for vertical incidence. On completion of a mission, the camera system, including film, is returned to Earth in a 2.2 m spherical descent capsule.

NRSC Investment

NRSC's total issued share capital is in excess of £2.5 million with British Aerospace owning 52.8%. Other holders include Logica (8.1%), Serco Space (8.1%) and Spot Image (6.1%).

In June 1994, Logica quadrupled its holding thereby entitling it to appoint two non-executive directors to the NRSC board.

Spy Satellite Data Release

On 24 February 1995 the CIA announced that it would declassify and release more than 800,000 satellite images of the Earth's surface collected over 12 years by reconnaissance satellites. The move is designed to let scientists in such fields as environmental protection and weather forecasting take advantage of years of Cold War spying.

cies. Earth RS is the main priority in current Government policy. BNSC work closely with the Department of Education and Science to develop RS materials for use within the secondary science curriculum. An information pack is provided and a newsletter published.

British National Space Centre, Bridge Place, 88/89 Eccleston Square, London SW1V 1PT.

Centre for Remote Sensing at Imperial College provide courses and research in Earth RS.

The Chairman, Centre for Remote Sensing, Imperial College of Science and Technology, The Blackett Laboratory, Prince Consort Road, London SW7 2BZ.

The Remote Sensing Society is the specialist scientific society in the field. They provide an information service, hold meetings to discuss educational aspects of RS and provide advice to teachers.

The Secretary, Remote Sensing Society, c/o Geography Department, The University of Nottingham, Nottingham NG7 2RD.

British Interplanetary Society promotes Space and Astronautics in general. Its members are both professional and amateur enthusiasts. As well as its technical Journal, it publishes *Spaceflight*, the popular international magazine of space and astronautics. *Spaceflight* contains regular news of RS launches, equipment and applications etc. It is available on subscription from the Society or from bookstalls.

British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Acknowledgement

The contribution of Max Wholey in the preparation of the diagram is gratefully acknowledged.

'Commercial Launchers' Competition

The market for commercial launchers is currently estimated at \$15 billion annually. Not surprisingly there is escalating competition around the world to obtain a share of this market, some 62% of which is cornered by the Ariane launcher. With more launchers now in the news than ever before, there is opportunity for readers to do a bit of vehicle spotting again and perhaps win a prize. A similar competition in the August 1994 issue proved to be very popular.

Prizes: The first correct entry to be opened after the closing date of 1 June 1995 will receive a copy of the book (published by Huth Lauter Levin Associates Inc, 1993):

Space Discovery and Exploration

Eds Martin J. Collins and Sylvia K. Kraemer

The runner up will receive a copy of the book (published by Cambridge University Press, 1994):

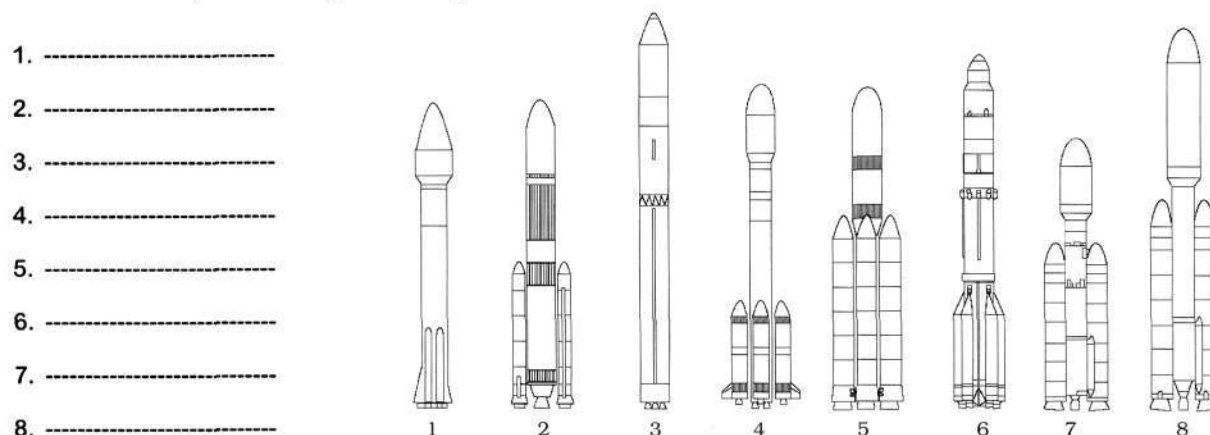
The Observer's Guide to Astronomy (Volumes 1 and 2)

Edited by Patrick Martinez

Three consolation prizes are offered of the book:

Citizens of the Sky - by BIS Fellow Bob Parkinson

To Enter: Match up the following line drawings with the list of names below:



H-2; Atlas 2AS; CZ (i.e. Long March) 2E; Proton;
GLSV; Titan 3; Zenit 3; Titan 4.

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 1 June 1995.

Entries may be submitted on a photocopy or otherwise
written out in a clear and unambiguous form.

Title/Name

Address

Spaceflight Crossword

No. 21

ACROSS

1. Shuttle pallet satellite (acronym)
3. Monument
9. External
10. Eight-sided figure
11. Pull along
13. Misery
14. Non-metric unit of weight
15. Turn
17. Engage for service
19. Top of a wave
20. Metal
22. At a distance within view
24. Storage cupboard
25. Sees
27. Improve by practice
28. Earth

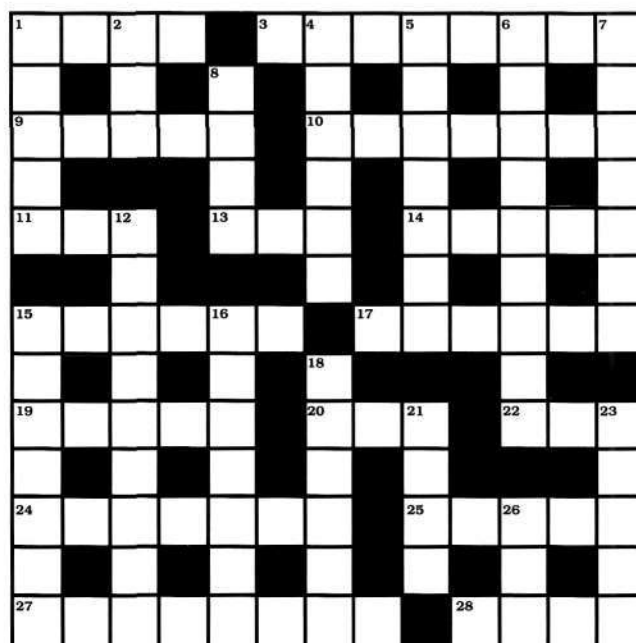
DOWN

1. Early solid-propellant space launch vehicle
2. Likely astronaut ?
4. Runaway
5. Obsolete
6. Ability for invention
7. Most extensive
8. Shuttle flight team
12. Astronaut who took a close view of Mir
15. Process for use again
16. Gigantic
18. Specifies
21. Star that suddenly brightens
23. Japanese space agency (acronym)
26. Letter of the Greek alphabet

Solution will appear in the June issue.

Solution to Crossword No.20.

ACROSS: 1. Olbers; 4. Kourou; 7. Ursa Minor; 9. Ions; 10. Sega; 11. Safer; 13. Soviet; 14. Rifled; 15. Circle; 17. Blocks; 19. Sprue; 20. Near; 22. Heat; 23. Launch pad; 24. Stream; 25. Indian.
DOWN: 1. Orbits; 2. Ears; 3. Seasat; 4. Kuiper; 5. UFOs; 6. Unpaid; 7. Universal; 8. Reflected; 11. Seals; 12. Rille; 15. Canoes; 16. Eponym; 17. Buchli; 18. Saturn; 21. Rare; 22. Hard.



SATELLITE DIGEST-276

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Design	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Discovery	1995-004A	Feb 3.22	KSC	Shuttle	95,853	Feb 6.85	51.65	92.35	387	392	[1]
SPARTAN 204	1995-004B				1,167	Feb 8.06	51.65	92.32	388	388	[2]
ODERACS 2A	1995-004C				5	Feb 6.52	51.64	91.33	329	351	[3]
ODERACS 2B	1995-004D				4.25	Feb 7.53	51.65	91.25	323	349	
ODERACS 2C	1995-004E				0.53	No orbital data issued					
ODERACS 2D	1995-004F				1.5 g	Feb 11.07	51.64	91.06	317	336	
ODERACS 2E	1995-004G				1.5 g	Feb 11.07	51.64	91.12	320	339	
ODERACS 2F	1995-004H				0.5 g	No orbital data issued					
Progress-M 26	1995-005A	Feb 15.70	Tyuratam	Soyuz	7,250 ?	Feb 18.01	51.65	92.45	391	397	[4]
Foton 7 (F10)	1995-006A	Feb 16.74	Plesetsk	Soyuz	6,200 ?	Feb 16.85	62.81	90.40	220	369	[5]

NOTES

1. STS-63 shuttle mission carrying six astronauts: J.D. Wetherbee (commander), E.M. Collins (pilot - first woman to pilot a shuttle), B.A. Harris Jr (payload commander, mission specialist MS-1, EVA crewman EV-2), C.M. Foale (MS-2, EV-1), J. Voss (MS-3) and V.G. Titov (MS-4, second Russian to fly on a shuttle). Shuttle performed a rendezvous with Mir Complex 1995 February 6, manoeuvring to a distance of 10 metres from the station February 6.81. Shuttle "parked" over the longitudinal docking port of the Kristall module which is docked radially with the Mir core module, this port being planned to be used for the Atlantis (STS-71) docking mission with Mir in June 1995 (by this time Kristall will have been re-located to the front longitudinal port of the Mir core). Fixed payload in the shuttle's payload bay was SPACEHAB-3, mass 3,976 kg, used to permit easy access to space for commercial and other microgravity experiments. Shuttle landed at Kennedy Space Center 1995 February 11.49.
2. SPARTAN 204 (Shuttle Pointed Autonomous Research Tool for Astronomy) was initially deployed while remaining attached to the shuttle's remote manipulator arm during 1995 February 4: during this period it was pointed at the shuttle's tail to observe its surface glow: it was also pointed at one of the shuttle's reaction control thrusters (RCS) to obtain far-ultraviolet spectrographs of the thruster firing. Second part of SPARTAN operations were in free-flight. It was deployed from the shuttle 1995 February 7.52 and re-captured 1995 February 9.48: during the period of freeflight ultraviolet region astronomical observations were conducted. Returned to Earth aboard Discovery.
3. Second flight of ODERACS (Orbital Debris Radar Calibration System) satellites, the first being aboard Discovery/STS-60 in February 1994. The small satellites are to be used to test the tracking capabilities of ground-based radar and optical sensors, allowing those measurements to be calibrated with small objects of a known size and composition. Three ODERACS-2 satellites are spheres of different diameters and the other three are dipoles of platinum alloys. ODERACS 2E decayed from orbit 1995 February 27.
4. Unmanned cargo freighter, carrying supplies to the Mir cosmonauts as well as 100 kg of equipment to be used by United States astronaut Norman Thagard during his visit to Mir. Spacecraft docked with the rear port on the Kvant 1 module at the rear of the Mir complex 1995 February 17.77.
5. Tenth Foton satellite to be launched (the launch announcements referred to it as "Foton 10"), although only the seventh satellite to carry the Foton name: first three flights were within the Cosmos programme (see comments included in Satellite Digest 275 regarding the previous Foton mission). Spacecraft launched to undertake materials processing experiments, permitting the manufacture of high-quality semi-conductors and variable-refraction lenses. Also carries the ESA Biobox-2 incubator with experiments from Belgium, France, the Netherlands, Spain and Russia concerning the cells responsible for bone mineralisation and on small living organisms (algae and fruit flies), as well as the French Ibis equipment (for CNES) which carries shrimps and urchin larvae to be used for studies into the effects of gravity on the formation of the nervous, vision, hearing and muscular systems.

ADDITIONS AND UPDATES

- 1983-073A Molniya-1 58 decayed from orbit 1995 February 23.
- 1983-077A Telstar 301 stabilised its orbit over 20 °E during February 1995.
- 1989-062A TVSat 2 was manoeuvred off-station over 340-341 °E approximately 1995 February 10-11.
- 1990-016A Raduga 25 was manoeuvred off-station over 69-70 °E during 1995 February 26-27.
- 1993-029A Cosmos 2244 was manoeuvred off-station during 1995 February 13-14 and has been retired. Add the following orbital data (the first is the operational orbit): 1995 February 13.10, 65.02°, 92.78 minutes, 402 km, 419 km, 1995 February 14.61, 65.02°, 90.98 minutes, 229 km, 416 km. The satellite is now decaying from orbit. This leaves Cosmos 2258, Cosmos 2264 and Cosmos 2293 as the operational EORSAT constellation.
- 1994-006G ODERACS F decayed from orbit 1995 February 24.
- 1994-006H BREMSAT decayed from orbit 1995 February 12.
- 1994-022A GOES 8 was manoeuvred off-station over 268-269 °E approximately 1995 February 2.
- 1994-035A The first sets of orbital data for UFO 3 (USA 104) appeared in January 1995. Add the following orbital data: 1995 January 18.52, 4.87°, 1,436.01 minutes, 35,772 km, 35,797 km.
- 1994-063A Soyuz TM-20 with Mir cosmonauts Viktorenko, Kondakova and Polyakov undocked from the Mir Complex 1995 January 18.37, retreated to a distance of 160 metres and redocked with the Complex at the same port (front longitudinal) 1995 January 18.39: the exercise was to check the automatic docking system which had failed during the spacecraft's docking in October 1994 (that docking had to be performed manually).
- 1994-067A Ekspress 1 was relocated over 345-346 °E approximately 1995 February 11.
- 1994-075A Progress M-25 undocked from the Mir Complex and was later de-orbited 1995 February 16. No Russian announcements giving the undocking and deorbit details have appeared through to the end of February, and the fate of the recoverable Raduga capsule is unknown.
- 1995-001A INTELSAT 704 stabilised its orbit over 65-66 °E in late February 1995.
- 1995-003A Add the following orbital data for UFO 4: 1995 February 4.02, 5.24°, 1,400.47 minutes, 34,225 km, 35,948 km; 1995 February 7.38, 5.13°, 1,436.23 minutes, 35,645 km, 35,933 km. The satellite is located over 189 °E.

EXPRESS LAUNCH IN JANUARY 1995

Nothing has yet been catalogued from the EXPRESS 1 launch for January 15 1995, and it is unclear whether anything actually reached orbit, despite a German press release suggesting that orbit (albeit an incorrect one) had been attained.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

3 May 1995 7 - 8.30 pm

The Design, Instrumentation and Function of the Cassini Mission Titan Surface Probe (Huygens Lander)

Dr John Zarnecki
University of Kent

The Cassini Huygens mission to Saturn and Titan will be one of the major missions of space exploration of the next decade. The mission will be described with emphasis on ESA's contribution, the Huygens Probe, which will land on the surface of Saturn's largest moon Titan.

7 June 1995 7 - 8.30 pm

Magellan Looks at Venus

Prof Dan McKenzie
Department of Earth Sciences,
University of Cambridge

For four years Magellan mapped the whole Venus surface with a resolution of about 100 m. We now have better maps of its surface

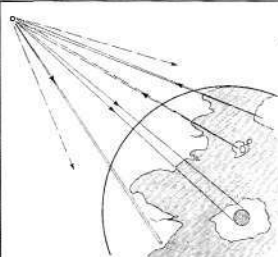
12 August 1995

50th Annual General Meeting

The 50th Annual General Meeting of the Society will be held at The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1, on Saturday, 12 August 1995 at 12 noon.

Admission is by ticket, available to Corporate Members (i.e. Fellows of the Society) only, who should apply in good time enclosing a stamped nomination envelope.

Council nomination forms are obtainable from the Executive Secretary. These must be completed and returned not later than 12 noon on Friday, 19 May 1995. If the number of nominations exceeds the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all Corporate Members.



ENJOY AN EVENING WITH ARTHUR C. CLARKE

in person at

The Scientific Societies Lecture Theatre,
Fortress House,
New Burlington Place, London W1

at 6.30 pm on 18 August 1995

The Society will present its Space Achievement Medal to
Arthur C. Clarke

in honour of his work, together with a special commemorative plaque to mark the 50th Anniversary of the concept of geostationary satellites advanced by Arthur in 1945.

◆ Buffet Reception

◆ Guest Speaker

Tickets are available to members at £20 per person. Early application should be made to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

26 April 1995 10 - 4.30 pm

Electronics in Space

Major advances in electronics in recent years have had an enormous impact on spacecraft design and on what can be accomplished in space within a given mass and volume.

This one-day symposium will cover the latest information concerning the effects of the space environment on advanced electronics systems.

3 June 1995 10 - 4.30 pm

Soviet/CIS Astronautics

The Soviet/CIS symposium is acknowledged as one of the foremost meetings for the presentation of material on current and historical reviews of the space programmes of the Soviet Union and its successor Republics.

13 September 1995 10 - 4.30 pm

Low-Cost Satellites

Many organisations have been trying to reduce costs substantially, mainly by the innovative design of micro- and minisatellites. Some of the topics relevant to this theme will be presented.

features and gravity than we do of Earth. Spectacular images of the surface show how different Venus is from Earth. Though the origin of many of the features is not yet properly understood, the gravity field has already provided some clues. Unlike Earth, the topography of Venus is dominated by mantle up- and downwelling. Perhaps the most important result of the whole mission is that it has shown us that we still have a great deal more to learn before we understand what controls the dynamics of rocky planets.

10 July 1995 7 - 8.30 pm

Australia in Space

J. Heyman
Western Australia

The lecture will commence with a discussion of Australia's early space history, including the development of Woomera, the sounding rocket programmes conducted at Woomera, the involvement with the British and ELDO space programmes, the cooperation with the US and the launch of Australia's own Wresat satellite.

The lecture will then discuss the limited activities from Wresat until the 90s and will finally have a look at the recent five year space plan promulgated by the Australian Space Council.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

CLASSIFIED ADS

SPACE BOOKS. magazines, photographs, newsletters, FREE lists. Geoffrey Falworth, 15 Whitefield Road, Penwortham, Preston PR1 0XJ.

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'Interstellar Probes' Competition Winners

Winners to whom video prizes will shortly be dispatched are:

Mr A. Depuydt	Belgium
Dr G. Isella	Italy
Mr W.G. Maxwell	UK
Mr P. Turpeinen	Finland

The correct answers are: 1. Pioneers 10 and 11; 2. Voyagers 1 and 2; 3. Pioneer 10, Pioneer 11, Voyager 2, Voyager 1; 4. Pioneer 10, Voyager 1, Voyager 2, Pioneer 11.

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As a member of the Society you will become part of a worldwide organisation which promotes space and astronautics and be able to attend the wide range of Society meetings, visits and other special events. Members also receive discounts on Society publications and entry to symposia.

This offer includes a choice of FREE GIFTS viz: official Society pin-on lapel badge, a voucher that entitles you to £5 OFF any title in the BIS Video Collection or a copy of the 218pp book *Citizens of the Sky* by R.C. Parkinson.

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PATRICK MOORE

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The BIS is proud to offer a stunning record of man's exploration of space brought to your home on video.
All videos are extracted from original footage.

STS-59: Mission Highlights

Launch Date: 9 April 1994

Perhaps the most challenging part of this shuttle mission was experiment SRL1, the first flight of the Space Radar Laboratory. To study the surface of the Earth with this instrument package Endeavour was required to make more than 400 separate position manoeuvres to achieve the ground track and orbiter alignment essential for radar mapping the surface and geology of the Earth. Other important tasks included tests of a new form of video-microscope capable of studying biological processes, such as cell growth and movement, under zero-G conditions. Pollution studies included mapping the global and local distributions of CO important in the study of ecology and the ecosphere. There are a number of spectacular SRL1 Earth views. 59 mins

STS-60: Mission Highlights

Launch Date: 3 February 1994

This Discovery mission included Russian cosmonaut Sergei Krikalev and marked the start of a new era of USA and Russian Cooperation in Space. The mission carried the Spacehab module and a three-dimensional gravitational accelerometer. Other experiments included the study of crystal growth under zero-G, the deployment of BREMSAT and the launch of six Orbital Debris Radar Calibration Spheres (ODERACS), ranging from 5 to 15.2 cm in diameter. 58 mins

STS-64: Mission Highlights

Launch Date: 9 September 1994

The 19th flight of Discovery conducted a diverse range of experiments concerned with Earth environment monitoring technology. The mission included the release and recovery of the 2800 pound SPARTAN satellite. The mission included extended EVA activities. Nitrogen propellant recharging of the astronauts' manoeuvring unit, the SAFER (Simplified Aid for EVA Rescue), is shown. Its manoeuvring ability and its attitude control system are impressively demonstrated. The mission also included a series of atmosphere monitoring experiments with the Lidar in Space Technology Experiment (LITE) instrument. 1 hr 4 mins

STS-65: Mission Highlights

Launch Date: 8 July 1994

STS-65 was the 17th trip into space made by space shuttle Columbia which spent 14 days in orbit. The mission conducted a wide range of experiments concerned with biochemical, biological and human physiological processes in reduced to zero-gravity environments. The science crew included for the first time a Japanese woman as a mission specialist. The second International Microgravity Laboratory (IML2) science programme was made up of a number of experiments ranging from protein separation and electrophoresis, to the study of growth and breeding of fruit-flies in zero to 1G variable-gravity environments. The effects of zero-G on the swimming orientation of goldfish, and the behaviour of adult Japanese Red Bellied newts and the growth of their embryos were among a range of aquatic experiments performed in a special unit called the AAEU (Aquatic Animal Experimental Unit) which was probably the first equivalent of an aquarium in space. The video includes some excellent views of Earth. There is only a limited sound commentary. 57 mins

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JBIS



The June 1995 issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

Cray Systems in Space (Part IV)

Perspectives on the Infrastructure Required to Routinely Exploit Earth Observation Data for Monitoring European Coastal Waters

Cluster Mission Control System (CMCS)

Applying the ESA Software Engineering Standards to Small Projects

Real-Time Simulation of the Sax Spacecraft AOCS

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Accessing Space Data on the Information Super Highway

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The British Interplanetary Society
27/29 South Lambeth Road, London SW8 1SZ, England.

The RAE Table of Earth Satellites, 1957-1989

1056 pages, published in 1990. Original price £95.

The Society has acquired a stock of the RAE Table of Earth Satellites, a substantial volume originally published at £95 which it is now making available to members at the incredible price of £7.50 (US\$15), plus £4.50 postage and packing in the UK. £9 (US\$16) abroad.

The RAE specialised in the analysis of satellite orbits to determine the Earth's upper atmosphere density and winds, as well as its gravitational field. In order to choose suitable satellites, a listing was necessary, thus leading, over the years, to the present volume containing data on more than 17,000 satellites, including fragments, in 893 pages of tabulation. Extensive revisions have been made to this, the fourth edition, to include not only all new launchings to extend the period covered to 1989 but also to incorporate over 1,000 revisions to the earlier data.

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Front Cover: Launched from the Kennedy Space Center, the orbiter Atlantis will be taking a high inclination (51.6 degrees) orbital path to head for a rendezvous and docking with the Mir space station. The photo shows the nearly on-time lift-off of Atlantis on its previous mission in November 1994 following an approximately two-year absence during which it underwent extensive modifications to enable it to dock with Mir.

NASA



On 14 November 1994 Atlantis landed at Edwards AFB in California at the completion of the STS-66/Atlas-3 flight. The landing was diverted from the Kennedy Space Center in Florida because of poor weather there.

NASA

Atlantis Returns From Its Previous Mission

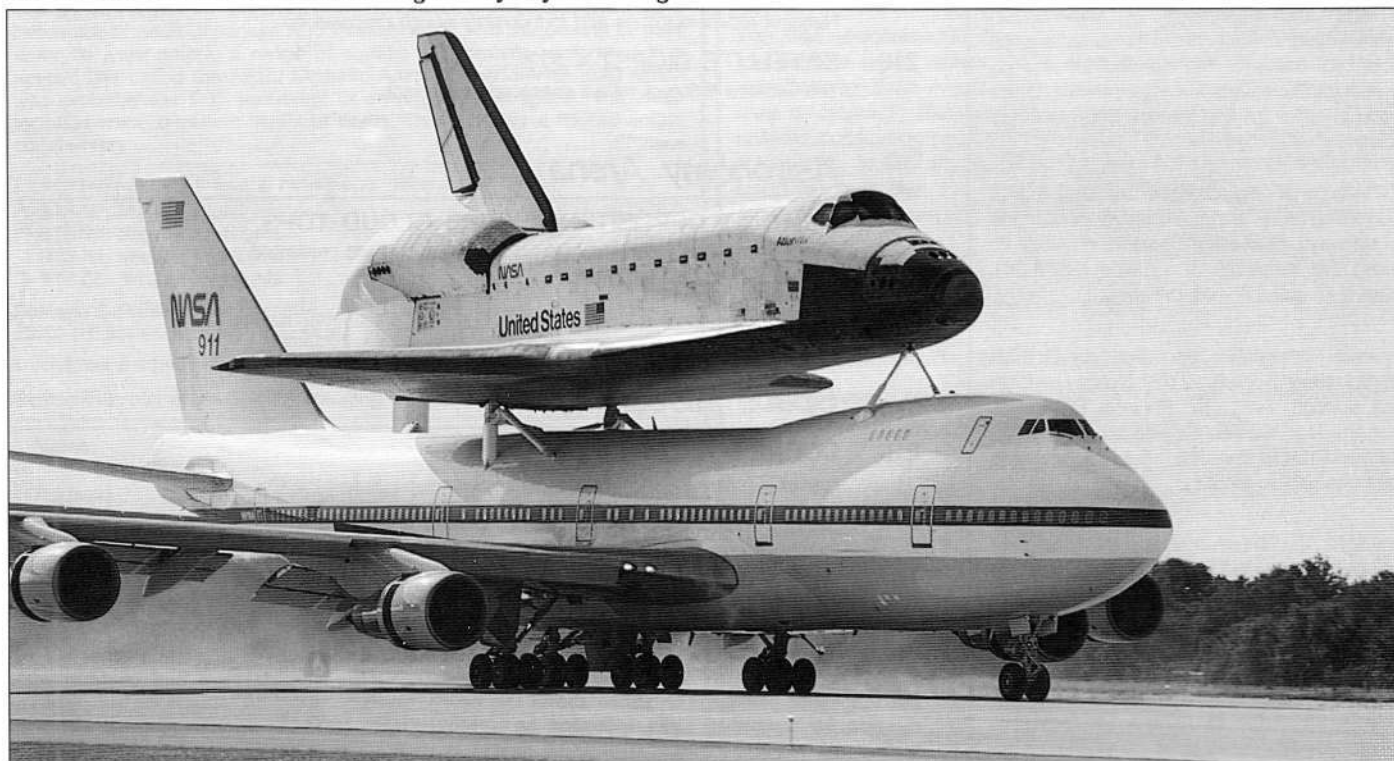
Right: Post-flight inspections of the orbiter showed 148 "hits" on the Thermal Protection System, of which 28 had a major dimension of one inch or greater. In addition an ice deposit on a waste water dump on the forward section of the left-hand payload bay door was still attached after landing and measured about 8 x 4 x 2 inches. Neither of these were processing issues affecting the STS-71 schedule.

PETER GUALTIERI, WEST KENTUCKY NEWS



On 21 November Atlantis began the ferry flight back to KSC atop the NASA Boeing 747 at around 1430 GMT. The ferry flight stopped off en route at Kelly Air Force Base, San Antonio, Texas. The 747 had to land at Eglin AFB in Florida's panhandle because of weather constraints at KSC. The next day the 747 arrived at the KSC shuttle runway at 1521 GMT (1021 EST). The orbiter was demated from the 747 and towed to Orbiter Processing Facility Bay 3 that night.

PETER GUALTIERI, WEST KENTUCKY NEWS



Hand-Shakes in Space

First Shuttle-Mir Link-Up

New Docking System is Next Step in Space Station Cooperation

History is shortly to be made in low-Earth orbit as two giant space vehicles built half a world apart join together and crews are exchanged aboard the world's only manned space station. The docking between the American Space Shuttle Orbiter Atlantis and the Russian Mir orbital complex is the first one in 20 years between American and Russian Spacecraft.

Introduction

In July 1975 the American Apollo and Soviet Soyuz craft docked for two days of handshakes, feasts and ceremonies which were supposed to celebrate a gradual thaw in the tensions between the world's two deadliest superpower rivals.

Space was the High Ground where cosmonauts and astronauts competed to demonstrate the superiority of one political system over the other. In that race the Americans beat the Soviets to the glittering prize - the Moon Landings.

But by 1975 the Moon landing flights were history, victims of financial prudence and political alienation. The Soviet Union needed a demonstration that, after losing the Race to the Moon (although officially denying that it had ever competed in a race), they were still the equals of the Americans in space having chosen "Their Way" of building permanent orbiting space stations.

The 1975 mission, despite hopes to the contrary, was just politics and over the next two decades the Americans and the Soviets, later the Russians, pursued their own courses in space.

The Americans developed their versatile Space Shuttle fleet with a view to servicing a gigantic orbital facility whilst the Soviets kept a series of small space outposts manned periodically. However, even before the Soviet Union collapsed at the end of 1991 it was becoming apparent that the two superpower rivals were being forced to become partners.

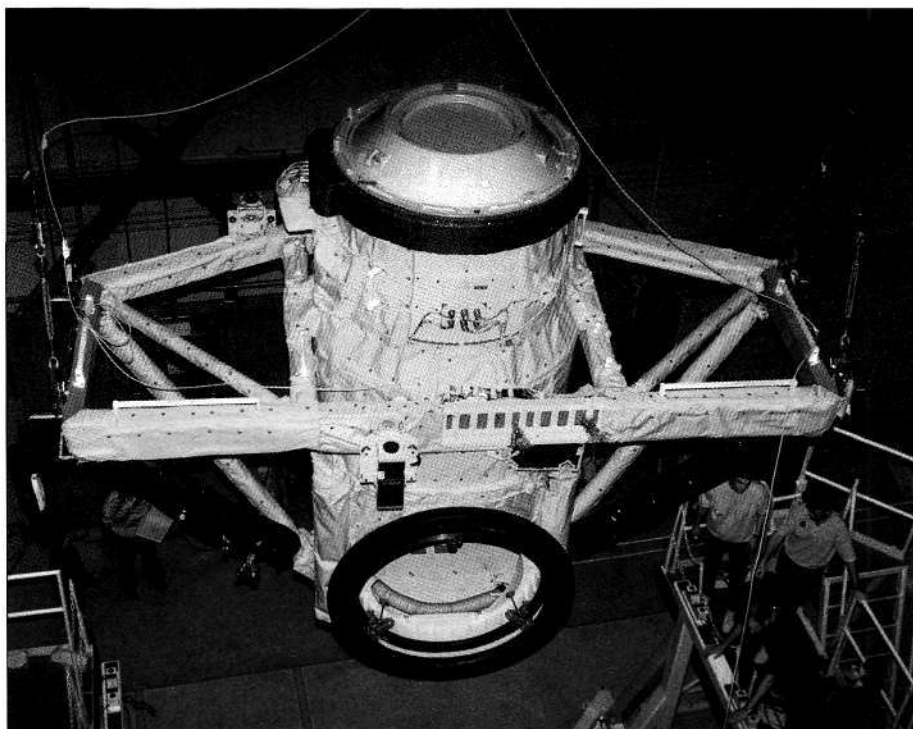
The International Space Station "Freedom" went through many changes in design and the Russians were forced by both financial and technical reasons to stretch out the development of their permanently manned Mir complex.

Cooperation in the development of a joint space station utilising the skills and expertise developed by both nations' programmes was an idea whose time had come.

Shuttle-Mir Missions

STS-71, NASA's 101st crewed space mission, is the first of up to seven Space Shuttle missions to Mir that are planned under a cooperative agreement between NASA and the Russian Space Agency (RSA).

A \$400 million contract signed by the agencies provides funding to Rus-



In the Orbiter Processing Facility Bay 3, the Orbiter Docking System (ODS) is installed in the payload bay on 13 March. The ODS includes an airlock, supporting truss structure, a docking base and a Russian-built docking mechanism (uppermost). It is nearly 4.6 m wide, 2 m long and 4.1 m high and weighs more than 1,588 kg. It is installed near the forward end of the orbiter's payload bay and connects by a short tunnel to the existing airlock inside the pressurised crew cabin. Installation takes about two hours to complete. NASA

BY NEVILLE KIDGER

Leeds, UK

sia for activities under the protocol to the Human Space Flight Agreement which was signed in December 1993. The contract covers Russian hardware, services and data in support of a joint programme involving the US Space Shuttle and the Russian Mir Space Station, and selected requirements for the International Space Station.

The Russian firm NPO Energiya was contracted to supply the docking ring for the actual structure that will be used to link the shuttle and Mir crafts. Preparatory work has included flights of two Russian cosmonauts, Sergei Krikalev and Vladimir Titov, on the American shuttle and a close approach to Mir by the orbiter Discovery in February 1995.

The American astronaut Doctor Norman Thagard became the first American to board the Mir station on 16 March 1995 following his launch with Vladimir Dezhurov and Gennadi Strekalov as the Mir-18 crew.

That crew has the task of preparing

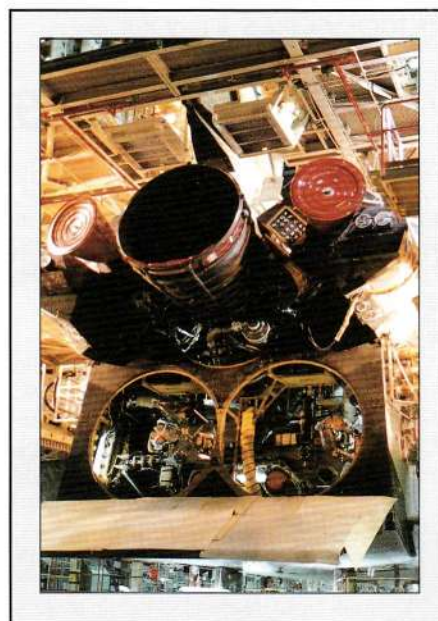
the complex to receive the American shuttle. Their mission will culminate with the docking of Atlantis.

Atlantis Processing Milestones

The campaign to ready the Orbiter Atlantis for the first Shuttle/Mir docking had few opportunities for the schedule to slip to meet a target launch date that had been set for early June 1995. There was a slight slip in the overall schedule when it was announced in December that the Spektr module's launch was to be delayed from February to May.

In addition to the normal preparations of the orbiter for flight there was the unprecedented task of integrating the Orbiter Docking System (ODS). A further task was the installation in the orbiter of the Spacelab-Mir module which, in addition to being used for medical tests, would also serve as a storehouse for consumables being delivered to the Mir complex. NASA's Conrad Nagel was in charge of the processing team and the schedule went ahead as follows:

● 25 November 1994: The ODS arrived from Rockwell and was taken to the Vehicle As-



Atlantis on 23 March when turbo pumps on two SSME's were replaced as a precaution when cracks in the volute liner of a test engine were found. The engines were removed and sent to the VAB SSME refurbishment area. The turbo pump on the remaining engine can be seen just below the bell nozzle. The OMS engines can be seen with their red covers on either side of the remaining engine. The body flap is seen below the two engine holes and the tail rises above the top engine.

PETER GUALTIERI, WEST KENTUCKY NEWS



Above Left: On 13 January when experiment racks were being installed in the Spacelab module in the Operations and Checkout Building.

NASA

Left: The interior of the Spacelab module seen with racks fitted (in February 1995) and waiting for its installation in the payload bay of Atlantis which began on 22 March.

E. RUDOLF VAN BEEST



Below Left: On 21 March, STS-71 Mission Commander Robert L. "Hoot" Gibson (left front), KSC payload processing team member Kevin Flautt (centre) and Pilot Charles J. Precourt pose with the Russian-built Androgynous Peripheral Docking Assembly (APDA) that is an element of the Orbiter Docking System (ODS) in the payload bay of the Space Shuttle Orbiter Atlantis. On flight day three, Atlantis will dock with the Russian Mir space station. The APDA on the space station will lock with the one aboard Atlantis to provide the means to keep the two spacecraft together. Docking operations will continue until flight day eight of the 11-day mission.

NASA

sembly Building where it was uncrated and inspected over the following days. The orbiter's structure was checked, payload bay doors opened and mid-deck payloads removed over the following days.

● **Mid-December:** The electrical configuration of the forward bulkhead for the ODS was checked and operations were underway for the hypergolic deservicing of the Orbiter Manoeuvring System (OMS) and Reaction Control System (RCS) jets.

Two RCS jets had shown problems on STS-66 and work was underway to troubleshoot this problem and others related to the General Purpose Computer no. 1 and the Ku-band antenna. The three Auxiliary Power Units (APUs) were being removed. The Spacelab module's systems were tested and experiment racks continued to be installed. Work was suspended over the Christmas holiday.

● **5 January 1995:** Work began to install Russian-made control panels into the orbiter to operate the docking device for mating with Mir. The three main engines were to be removed and preparations made for the installation of the APUs.

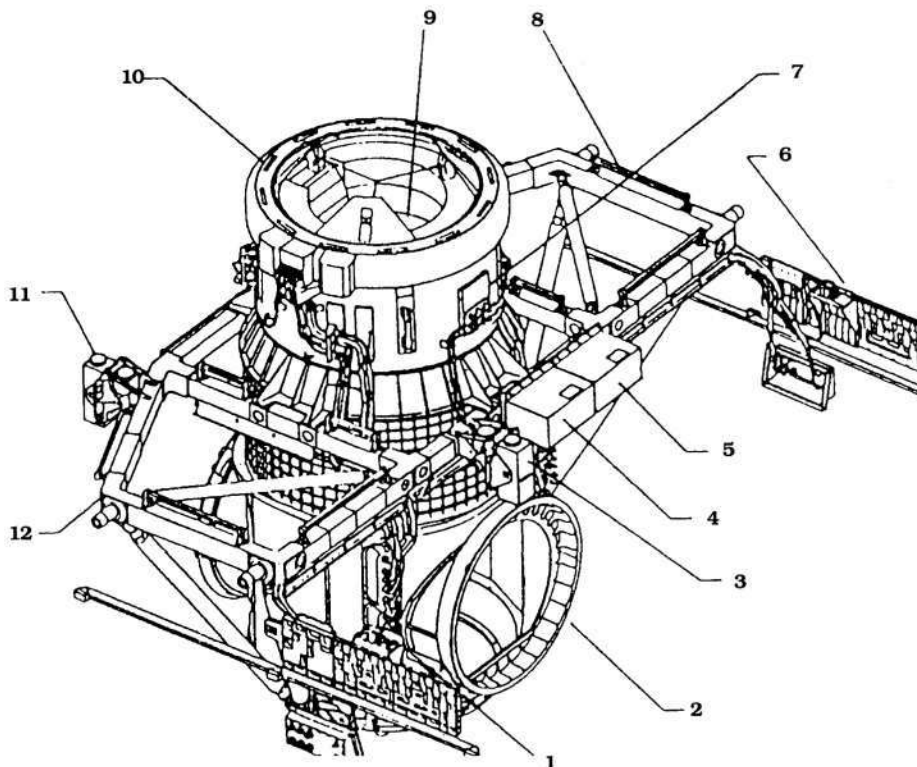
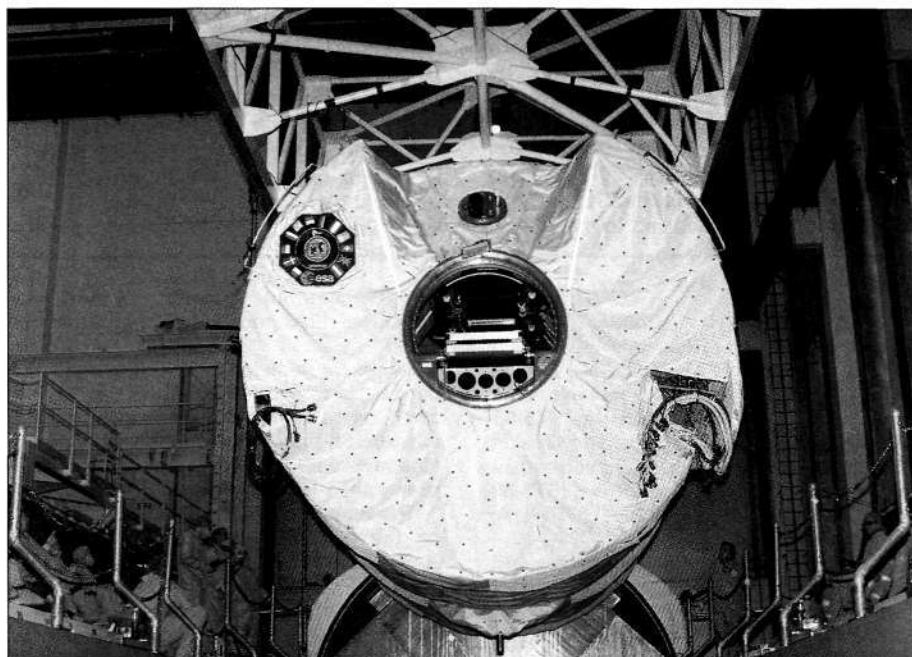
● **12 January:** In the VAB a team of Russian engineers began work to remove and replace six ball screw housings on the ODS. The engineers had come to change the system of shock absorbers because a flaw had been discovered in them which was not a flight safety concern but might have hampered the docking. The changeout was expected to take about a week to complete. Energiya redesigned the shock absorber housing following tests in Russia which revealed that the device may work incorrectly in space. Over the next two weeks inspections of the orbiter's Thermal Protection System (TPS) were made along with a functional test of the docking system.

● **13 January:** The experiment racks were being installed in the Spacelab module. Work begins on testing the electrical connections.

● **26 January:** Work continued on testing the power reactant storage and distribution

On 20 March, the Spacelab module is lowered into a payload canister in the Operations and Checkout (O&C) Building for transport to Orbiter Processing Facility (OPF) high bay 3. There, it was integrated into the payload bay of Atlantis. The module will serve as an orbiting medical laboratory for joint US-Russian medical investigations on the effects of long-duration space flight on mission crews.

NASA



Orbiter Docking System. Key: 1. Payload panel; 2. External airlock; 3. TV target Camera (Buran); 4. Trajectory Control System (TCS)no.1; 5. TCS no. 2; 6. Payload panel; 7. Docking base; 8. Handhold; 9. Centreline camera light assembly; 10. Docking mechanism (Supplied by NPO Energiya); 11. Soyuz target camera; 12. Truss.

ROCKWELL INTERNATIONAL

systems, servicing the orbiter's potable water system and repositioning of the waste water dump nozzle.

● **31 January:** The Spacelab endcone was installed. Work was underway to test the orbiter's two OMS pods.

● **14 February:** The Spacelab Interface Verification Test between the experiment racks and the Spacelab module was completed. Over the next few days the high data rate recorder was installed and tested. The ergometer and treadmill were mounted in the Spacelab module's centre aisle.

Also on this day it was revealed that the

orbiter's air conditioning system would need major repair which would affect the day-to-day schedule but not the overall one. An egg-shaped bulge was discovered by the processing team in the system's interchanger. Without knowledge of the cause of the bulge the processing team decided to replace the interchanger which uses Freon to chill water to cool the orbiter crew cabin. Nagel said the decision to exchange the device came after "lots of discussions and hand-wringing". To round out a busy day the orbiter's drag chute, which deploys from the tail during landing roll-out was installed.

● **Mid-February:** In the VAB's high bay 1 the twin solid rocket boosters continued to be stacked. Work began on installing the three main engines. Their serial numbers are: SSME 1: 2019; SSME 2: 2034; SSME 3: 2032.

● **24 February:** The treadmill in the Spacelab centre aisle, which had been removed for trouble shooting, was re-installed. Other Spacelab milestones scheduled included an Integrated Compatibility Test and the Crew Equipment Interface Test.

● **9 March:** ODS and Spacelab are declared ready for installation in the Atlantis Payload bay. The coming week will be "our most significant week so far in preparing the orbiter midbody for flight", announced Conrad Nagel. The Spacelab tunnel adapter and tunnel extension were installed.

● **13 March:** The ODS is installed in the payload bay of Atlantis whilst managers announced that discussions were underway on whether to replace one or more of Atlantis' main engines because of concerns with the high pressure fuel turbo pumps. No impact to the schedule was expected if the changeout became necessary.

● **14 March:** Managers announced that they would remove SSME 1 and 2 of Atlantis' main engines in order to inspect two high

pressure fuel turbo pumps for potential cracks on the volute liner, a "pressure vessel" at the discharge end of the fuel pumps.

● 16 March: In the VAB the External Tank (Number 70) was mated with the twin solid rocket boosters. In the OPF the ODS began a series of integrated power verification tests with the orbiter. In the Operations and Checkout building the Spacelab-Mir module was unable to be hoisted from the test stand for installation in the payload canister due to the unusual centre of gravity associated with it. The ground support equipment would have to be modified pending a further attempt.

● 22 March: Spacelab-Mir is installed in the payload bay of Atlantis and over the following days integrated verification tests were made. The flight crew were at KSC to conduct tests of the ODS centre-line camera alignment.

● 24 March: The three main engines were being secured along with electrical work to connect the Spacelab to the orbiter and leak checks of the cabin crew.

● 29 March: The STS-71 flight crew was scheduled to be at KSC to test out the ODS docking system with a ground mock-up of the Kristall docking ring. However rain storms kept them in Houston and the tests were performed by veteran astronaut Joe Engle who was at KSC as an observer. The test, observed over several hours by US and Russian engineers, was not scheduled to be repeated and was a success. A video of the test was provided for the flight crew.

● 3 April: The Spacelab-Mir closeout was being completed and the electrical interfaces of the orbiter RCS and OMS systems had been checked. The next day the tunnel connections and electrical checks were continued.

● 6 April: Due to the uncertainties regarding the launch date of the Spektr module NASA announced that the processing of orbiters Atlantis and Discovery would run parallel for either to be launched in early June to protect the schedule further down the timeline. The spacelab tunnel connecting the module with the crew compartment was installed. Checks of the seals found the tunnel would not hold pressure. Over the following days the tunnel was demated and a piece of thermal blanket was found to have caught in a flange. It was removed and new seals were installed. The new leak test proved successful. The spacesuits to be worn by Solovyov and Budarin were stowed in the Spacelab as the close-out activities with the module neared completion. The flight crew took part in the Crew Equipment Interface Test over the weekend of 8-9 April.

● 12 April: Work continued on the aft engine compartment close-outs. The mission emblems and flags were mounted on the Spacelab module.

● 18 April: The Orbiter payload bay doors were closed. Analysis conducted on two quality integrity seals near the base of the Orbiter Docking System delayed close-out operations and pushed the target move time to the Vehicle Assembly Building to 20 April.

● 20 April: The orbiter was rolled over to the Vehicle Assembly Building to initiate the mating of the orbiter to the SRBs and ET. Roll-out to Pad 39A was scheduled for 26 April. Launch was targeted for no earlier than June 19.

(To be continued in a forthcoming issue.)

Mir Modules' 'Musical Chairs'

The STS-71 mission is preceded by a vital rearrangement of the Mir modules, an exercise which continues after the flight and culminates with a full complement of modules docked to the Mir complex by the end of the year.

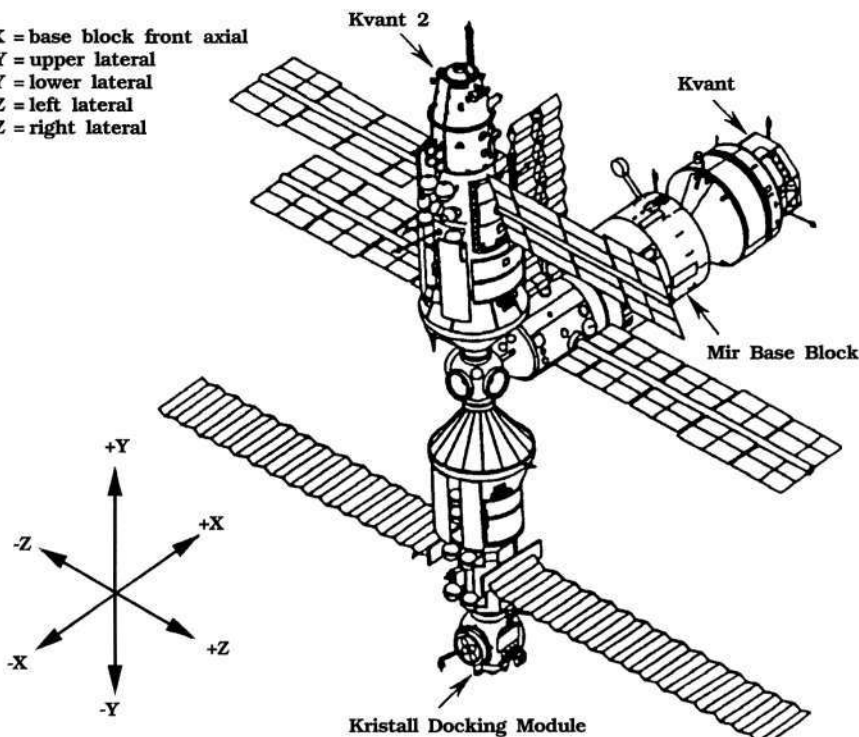
The following is a run-down of the events that must occur if the planned rearrangement of modules is to be reached.

The sequence begins in mid-May when cosmonauts Dezhurov and Strekalov conduct two EVAs to reposition the Kristall

and Kristall is moved back from the -Z to the -X port. Atlantis then docks with Kristall. (NASA managers have made contingency plans in the event of a delay or even a loss of the Spektr module.)

Following Atlantis' departure Kristall is redocked to -Z. The next arrival is

-X = base block front axial
+Y = upper lateral
-Y = lower lateral
+Z = left lateral
-Z = right lateral



Mir Station with axes illustrated.

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solar arrays to the Kvant astrophysics module.

Before Spektr docks an internal EVA shifts the cone of the base block's docking unit from the -Y axis to the -Z. An internal EVA is one in which the multiple docking adapter (MDA) is depressurised but the cosmonauts do not actually go outside the MDA. Kristall is then moved to the -Z port by way of the -X port, where it will be parked for a day or so, by means of the small manipulator system mounted on the module.

Spektr is due for launch on a Proton rocket from Baikonur on 20 May and docks six days later with the -X port.

Spektr is then transferred to the -Y port

Progress M-28 and an EVA is scheduled to place equipment on Spektr. The Progress will carry equipment for ESA's Euromir-95 mission of Thomas Reiter which will last 135 days and involve an EVA to position equipment on Spektr.

Atlantis' next docking is with Kristall at the -Z port. The STS-74 mission will leave a docking unit attached to Kristall.

Another EVA is planned for November to shift another docking cone. Priroda is then launched and docks with the -X axis being moved later to the +Z port.

This should leave the following:

-X Soyuz ferry;	+X Progress
+Y Kvant-2;	-Y Spektr;
+Z Priroda;	-Z Kristall.

About the Crew

The Commander is **Robert "Hoot" Gibson**, a veteran of four previous Space Shuttle missions (STS 41-B, 61C, 27 and 47). The pilot is **Charles Precourt** who flew in the same role on the STS-55 Spacelab-D mission in 1993. The Mission Specialists are **Ellen Baker**, veteran of STS-34 and 50; **Greg Harbaugh** (STS-39 and 54); and **Bonnie Dunbar** (STS-61A, 32 and 50).

Baker and Harbaugh are designated EV2 and EV1 respectively in the event that an EVA is required. Harbaugh was the back-up EVA crewman for the spectacular

STS-61 Hubble Repair mission in December 1993 prior to his assignment to STS-71.

Dunbar completed her assignment as back-up to Norman Thagard on the Mir-18 crew on 14 March with the launch of that mission. She had trained in Star City near Moscow with Thagard for a year in preparation for that mission.

The American crew of five will be joined on the mission by the Mir-19 crew of **Anatoli Solovyov** and **Nikolai Budarin**. They will stay in space whilst the Mir-18 crew returns with the Atlantis crew to America.

STS-71 Docking Plans

Launch of STS-71 is set for 19 June at 6:43 pm EDT. The launch window is just 5 minutes long.

Docking will occur two days after launch after Atlantis flies an R-bar approach to rendezvous with the Mir station. Neville Kidger has the details.

The orbiter's rendezvous radar is used to bring the orbiter to within 33 m of the Kristall port. Gibson is then to guide the orbiter to a position directly in front of the Kristall module on an imaginary line drawn along the Mir's direction of travel called the V-bar.

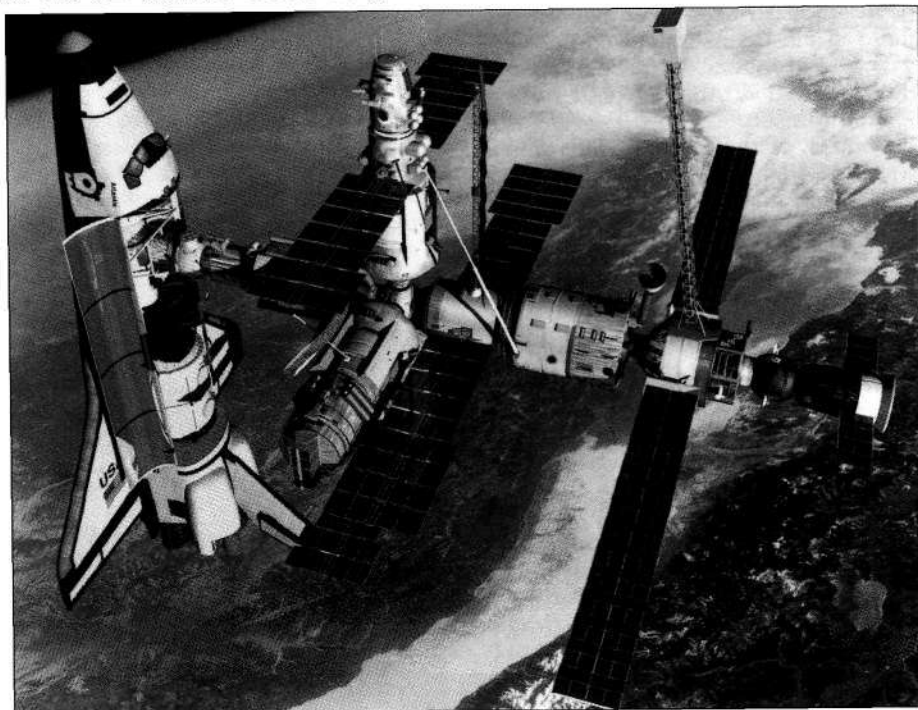
During the final approach phase Gibson will use a camera mounted in the centre-line view of the Orbiter Docking System (ODS) which will transmit TV to the orbiter's aft flight deck.

In the rehearsal for the approach conducted by Commander James Wetherbee during STS-63 the camera was mounted in a window of the Spacehab module. British astronaut Michael Foale also used a hand-held laser to obtain range and rate information to complement the data available from the orbiter's rendezvous radar.

In discussion with the writer Michael Foale cast doubt upon the need for the laser devices commenting that the hand-held laser frequently gave incorrect ranges because of the failure to bounce off many of the Mir structures.

The closing rate for docking is to be no more than 0.1 foot per second, substantially less than that employed for Soyuz and Progress M dockings. The APDA on the ODS will attach with the APDA of the Kristall module.

Docking is scheduled for 21 June based upon a 19 June launch. The two commanders of the orbiter and



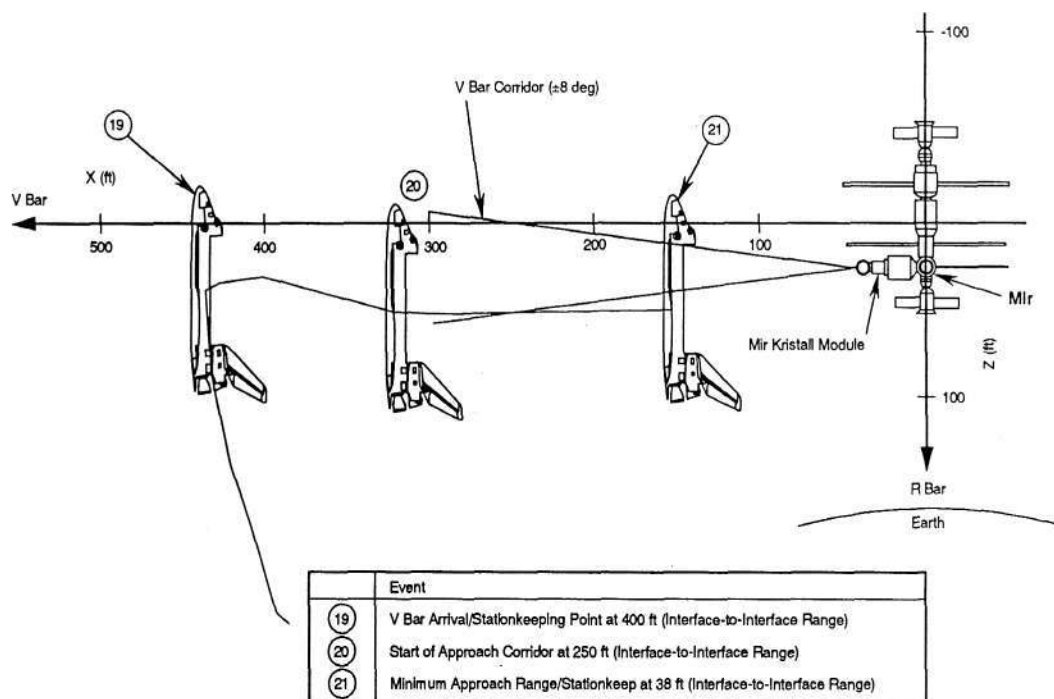
Computer simulation of the STS-71/Mir docking which clearly illustrates the Shuttle/Kristall configuration. The Spektr module is visible as a faint outline through the near solar panel. The module over the wing of the orbiter is Priroda which is not now due to arrive at Mir until later this year. NASA

station, Gibson and Dezhurov will make history when they shake hands in the Kristall module after crossing the threshold between the two craft. The Americans plan to bring flowers for their Russian hosts. The Americans will receive the traditional bread-and-salt greeting.

The Americans also plan to give candy and bread to the Mir-18 crew although vodka will not be delivered. (Sigmund Jaehn, a veteran Interkosmos cosmonaut states that there is vodka on Mir but that the cosmonauts on long missions only drink it occasionally and never to excess!)

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STS-63 +V bar station keeping and corridor approach from 400 ft to 38 ft.



Legally the two commanders will be in charge of the crews in their own craft and will give way to the commander of the other when in that craft. Gibson has said that he hopes on Mir the crews will speak Russian and on Atlantis English will be the primary language. The Atlantis crew have studied Russian, as have many more in the US astronaut corps.

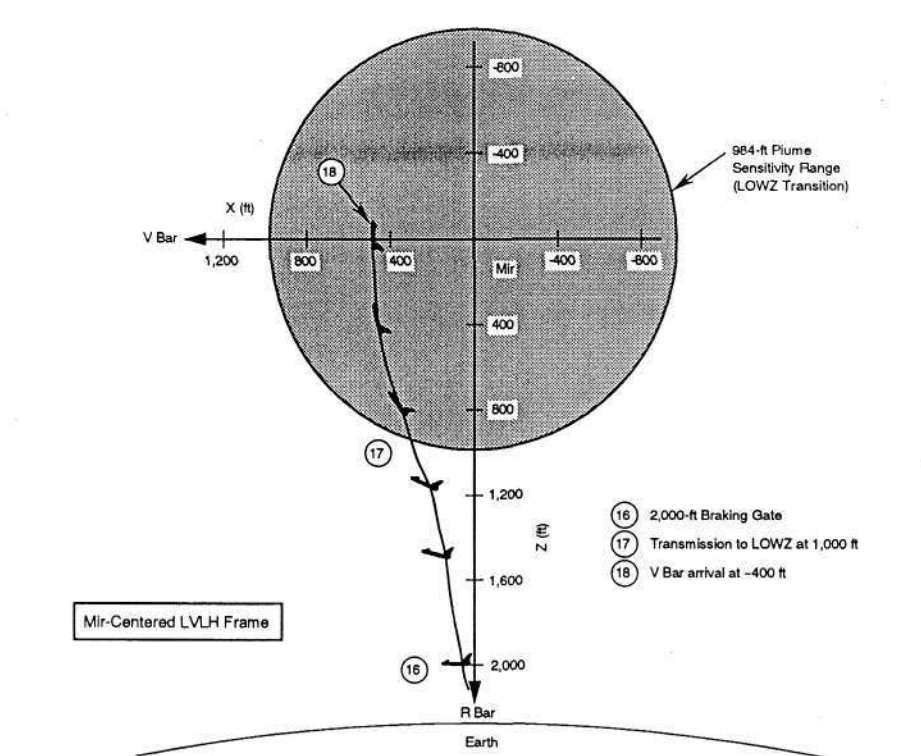
The astronauts and cosmonauts have trained in America and Russia for the mission.

Control of the orbiter will remain with NASA Manned Spaceflight Center in Houston and Mir will be controlled by the TsUP in Kaliningrad. Atlantis and Mir will be docked for 5 days and Atlantis will return to Florida closing out a mission lasting - 10 days 19 hours and 31 minutes.

During the docked period the Mir-18 crew will be subjected to extensive medical tests in the Spacelab module in the cargo bay of Atlantis. The module carries a treadmill and a lower body negative pressure garment in addition to other experiments and supplies.

For the first time, in a mission of many outstanding firsts, a shuttle crew will be larger when it returns than when it was launched with 8 people on board at the landing. Medical specialists are eager to make studies of the condition of the American Thagard as soon as possible following the landing and he will establish a new mark for American duration in space - 110+ days.

The Mir-18 crew will return to Earth in special reclining seats in the Atlantis mid-deck. The seats were tested in space by ESA astronaut Jean-Francois Clervoy on the STS-66 mission in No-



STS-63 Rendezvous: Mir manual phase profile.

ROCKWELL INTERNATIONAL

vember 1994, the previous flight of Atlantis.

Future Shuttle-Mir missions envisage crew swaps with Americans being taken to and picked up from Mir and EVAs to add to the capabilities of the complex. New power generating solar cells are a part of the payload of the second docking mission - STS-74 - which will deliver a new docking module to be attached to the Kristall module where all the planned dockings are to take place. In 1997 an EVA will feature two Americans and two Rus-

sians in a world first four person EVA.

Some critics have charged that the Shuttle-Mir programme does not feature much in the way of meaningful science. One of the shuttle's tasks is to deliver to the Mir station bags of water generated by the orbiter's fuel cells. Water is a valuable resource on the space station and is recycled. Extra supplies are delivered by the unmanned Progress cargo spacecraft.

Thanks to Mark DeCotis, Jim Banke and the Staff of *Florida Today* for their help.

Development of the Orbiter Docking System (ODS)

by Neville Kidger

Much interest has focussed on the progress of the design and manufacture of the ODS, being the first major joint engineering activity of the US-Russian agreement and therefore an indicator of likely progress in the future.

The 4-m high ODS is a joint product of NPO Energiya and Rockwell International who built the docking devices for the 1975 ASTP mission. The Russians supplied the docking mechanism called the Androgynous Peripheral Docking Assembly (APDA). Modified from the original unit procured for the Buran orbiter, it was built at Energiya's Kaliningrad factory. The assembly weighs about 1.6 tonnes.

The APDA was delivered to Rockwell on 11 September 1994 after many delays. Energiya was paid \$18 million under a fixed-price contract signed in 1993 which also covers a companion qualification unit, spare parts and technical services. The total cost of the ODS approaches \$100 million.

Problems with the pyrotechnic separation bolts became one of the delaying factors. It was determined in Russia that the bolts, of a military specification, were sus-

pect in performance at low temperatures. Performance data about the bolts was considered classified by the Russian vendor, which Energiya would not name.

The ODS has one bolt on each of the hook-and-latch connection points. The Kristall docking port has only half of this number rigged to separate pyrotechnically. Rockwell planned to test up to 4,000 of the bolts to determine their performance.

In the event of the bolts failing to fire the orbiter and Mir would remain locked together. NASA developed an EVA plan where, if this happened, astronauts would go outside the shuttle to loosen the 96 bolts that held the APDA to the docking base.

The APDA, covered in black thermal insulation material, was mated on to a docking base that attaches to a new external airlock designed to fit in the front of the orbiter payload bay supported by a truss structure. The external airlock connects with the existing airlock inside the crew cabin and with a Spacelab module.

Following integrated checkout at Rockwell, the Shuttle/Mir docking system

was delivered to NASA's Kennedy Space Center. There it was installed into the Space Shuttle Atlantis, which had been modified at Rockwell's Palmdale facility to allow it to accommodate the docking system.

Kent Black, Rockwell executive vice president and chief operating officer, called the ODS completion a major milestone in US/Russian cooperation. "Twenty years ago, Rockwell and Energiya created hardware joining two divergent cultures in space for Apollo-Soyuz, a one-time scientific and political mission", Black said. "Today, we have again joined to link the US and Russia in space, but this time it marks only a beginning." Rockwell Space Systems Division President Robert G. Minor called the company's work on the ODS programme both challenging and rewarding. "While there have been definite language, cultural and technical differences between us, we have found the Russian space community to be extremely cooperative, dedicated and professional. I think both sides have learned a great deal. That can only serve to benefit our respective programs in the future."

Thagard Joins Cosmonauts

Historic Step in Space Station Cooperation

Introduction

Veteran American astronaut Dr. Norman Thagard captured a unique place in space history books on 14 March 1995 when he became the first, and probably only, American to be launched into orbit on a Russian space vehicle.

Thagard was a member of Mir's 18th main expedition - the crew has been designated Mir-18 by NASA and the procedure will be followed in this article. Thagard accompanied two Russians, Commander Vladimir Dezhurov and Flight Engineer Gennadi Strekalov. The Reserve crew was Anatoli Solvyov and Nikolai Budarin of Russia and Bonnie Dunbar of the USA.

The main tasks for Thagard during his stay involve a series of biomedical investigations, during which the astronaut said he would be a "human lab rat", and helping the two Russian cosmonauts prepare the station for the arrival of a Progress cargo craft and the Spektr science module in April and May respectively.

The trio are scheduled to be brought back to Earth on board the US Shuttle orbiter Atlantis following the first American/Russian docking since July 1975.

Mir-18 is the first of several cooperative space flights that will involve visits by US astronauts to the Russian station. The missions, known as Phase One, will give the space programmes of the United States and Russia the opportunity to share experience and expertise gained in more than 30 years of space exploration. Phase One also lays the groundwork for the assembly of the International Space Station later this decade.

Though Mir-18 is a significant milestone in the Phase One activities, cooperation has been underway for several years. Cosmonaut Sergei Krikalev became the first Russian to fly on a US space shuttle in 1994, and Vladimir Titov repeated the feat earlier this year.

Astronauts Shannon Lucid and John Blaha are also in Russia training for visits to Mir in 1996. They are to be joined by Jerry Linenger and Scott Parazynski later. In contrast to Thagard, and contrary to earlier Russian reports, Lucid, Blaha, Linenger and Parazynski will be delivered to the station on the orbiter Atlantis and not aboard Soyuz missions.

Soyuz TM-21 in Flight

The Soyuz TM-21 spacecraft carrying Dezhurov, Strekalov and Thagard was launched at 0611 GMT on 14 March from a cold and windy but

BY NEVILLE KIDGER

Leeds, UK

sunny Baikonur Cosmodrome. The three men were to remain aboard Mir for three months taking over operations from the crew aboard the station in a continuation of the cycle of crew rotations begun in 1987.

A minor fire flared up at the pad



Norman E. Thagard.

NASA

following the launch fanned by gale-force winds driving the rocket exhaust on to the launching pad and not into the gas duct as was normal. As a result some equipment and cabling was destroyed but there were no casualties. Such fires are not uncommon but the strong winds, this time emanating from the north-east tore out lumps of melted asphalt. Military officers controlling the launch said they observed the carrier rocket move "for several seconds parallel to Earth" after it had cleared the launching pad.

During the pre-launch period, Thagard went through all of the Russian rituals including the official selection, press conferences, public suiting-up and speaking to his family before the walk out. He followed in the footsteps of all previous Salyut and Mir cosmonauts by taking part in the formal request to undertake the mission and personally watering the wheels of the bus which took the crews to the launch pad.

Thagard had told reporters that he was a crew member of a Russian spacecraft and expected that he would be treated as such. The call

sign of the crew was Uragan (Hurricane).

Thagard reportedly took with him several NASA-issue meals. Although the freeze-dried foods are not Earth-quality food, Thagard took them with him following remarks from former guest cosmonauts who described the Mir food as "hardly cuisine".

There was also concern about the power situation aboard Mir. During the previous joint mission, in October 1994 involving ESA's Ulf Merbold, there had been a power drain which had caused several days of anxiety. Thagard told reporters before the launch that he did not see the problem as serious or particularly dangerous, "If it were to happen, it wouldn't be that serious again."

The only personal effects he took with him, he told reporters, were family photographs. He also confessed that he might miss his Russian cat, a pet gathered during the year-long training at Star City where he lived during the period.

The Soyuz carrier rocket's flight path took the vehicle over Northeast Russia to a point about 405 km ahead of the Mir station. Over the next two days, Soyuz would slowly close the distance between the two spaceships until it eventually caught up with Mir from behind.

The rendezvous sequence began a little more than three hours after launch with the first of two manoeuvring engine burns that adjusted Soyuz's altitude and began the chase. The second burn occurred as planned about 90 minutes later.

A NASA statement noted that the rendezvous profile for a Soyuz space vehicle differed from a shuttle rendezvous profile in several ways. A Soyuz profile employs fewer, but longer manoeuvring burns and used an inertial approach for the docking - an inertial approach uses natural orbital dynamics to pull the vehicle toward the station. A shuttle profile has a large number of smaller burns, all targeted to bring the shuttle to a point about 15 km behind its rendezvous target at a specific time in its orbit. Docking is achieved by driving the vehicle slowly toward its target with a series of manually controlled jet firings.

As Soyuz was manoeuvred through the rendezvous profile Dezhurov, Strekalov and Thagard checked the systems needed for docking and collected a limited amount of biomedical data to help characterise the manner in which the human body adjusts to the microgravity environment of space. All systems on board Soyuz

MIR MISSION REPORT

were reported to be functioning as expected.

With the launch of the Mir-18 crew, a new record was set for the number of people in space at one time. Besides Thagard, Dezhurov and Strekalov, there were three cosmonauts on Mir and seven astronauts on the Space Shuttle Endeavour - STS-67. The Mir cosmonauts were flying over Central Africa when Soyuz TM-21 was launched, and the STS-67 crew was high above Indonesia. The cosmonauts on Soyuz had a "quiet" first day in space, NASA reported.

The crew fired the Soyuz's engines once, at about 07:11 GMT on 15 March, for six seconds to fine tune its course for the rendezvous. This was the third pulse of the Soyuz's engines in the rendezvous profile. Two more were scheduled the next morning for the approach to Mir. Soyuz was still half a world away from Mir, flying behind and below the space station in a 320 x 230 km orbit with a period of 89.8 minutes, inclination 51.6 degrees.

Progress M-26 Jettisoned

The cosmonauts on the Mir station, Aleksandr Viktorenko, Yelena Kondakova and Dr. Valeri Polyakov, were ready to welcome the new crew. The station's docking systems were checked and the unmanned Progress M-26 cargo spacecraft was released at 0257 GMT on 15 March and commanded to a destructive re-entry above the Pacific Ocean at around 0615 GMT the same day.

Communication sessions with the Mir-18 crew were brief and consisted mainly of exchanges of technical information. All three crew members talked to ground control teams, and all three were said to be feeling well.

Docking of Soyuz TM-21

Soyuz TM-21 docked without incident under automatic control with the rear port of the complex just after 0745 GMT on 16 March. The approach and docking were shown live on American TV.

Thagard was the first to be seen on TV inside the Mir base block about 90 minutes later as he was officially greeted by Elena Kondakova who kissed him on the cheeks and presented him with a special mat and the traditional bread and salt. An American flag was draped on the wall of the base block. Traditional Russian folk music was piped from the station during the brief exchange.

"We've been expecting your arrival for some time, and now you are on the station," Mir commander Alexander Viktorenko said. Thagard replied, in Russian, "I'm glad to be on the station and to see my friends."

Congratulations were then given to the crew from NASA Associate Administrator of Space Flight Wayne Little, NASA Shuttle-Mir Manager Thomas Holloway and Director General of the Russian Space Agency Yuri Koptev, who were watching the activities in the Kaliningrad control centre (TsUP) along with about 200 NASA and Russian space officials, guests and journalists.

NASA astronaut Frank Culbertson,

humans on orbit is signalling that we've got a whole new horizon just unfolding for us here with our joint space efforts, and we're real happy for you," said Oswald.

First Impressions

On 17 March Thagard spoke with the ground about the first day of their three-month mission.

To many "the ultimate dream is to put a man on Mars," Thagard said. "With such joint flights, it is entirely possible."

The doctor also reported that he had located all of the science equipment that was sent to Mir ahead of him. During his stay Thagard is to conduct a series of 28 scientific and biomedical experiments designed to characterise the human body's adaptation to the space environment. The experiments started on 17 March when the crew members took body mass measurements which would be compared to similar measurements taken throughout their stay on Mir.

There was more ceremony during the day when Russian Prime Minister Viktor Chernomyrdin visited the TsUP to congratulate the cosmonauts and pledge his support for continued cooperation in space with the United States.

There were, however, niggling problems which Thagard reported, none too serious. A freezer supplied by the European Space Agency had brackets unlike the model he had used on the ground trainer. Thagard had to remove the brackets to install a temperature sensor. Also, test tubes snapped when Thagard tried to put them into a restraint inside the freezer.

There was also discussion about the short cropped haircut that Thagard sported for the mission.

On the morning of 18 March the crew filmed the Earth's surface as part of the learning process of operating the Kvant-2 science apparatus.

On 19 March ITAR-TASS reported that the Mir-17 cosmonauts had checked the systems of the Soyuz TM-20 spacecraft and held sessions in the Chibis suit.

On 20 March a live press conference with the two crews saw questions being asked from Moscow and the Kennedy Space Centre in Florida, USA. Thagard facing the camera surrounded by the other cosmonauts said that he found the similarities between the US and Russian space programmes more striking than the differences.

The crews had decorated the walls with an American flag next to a Russian one and Thagard also placed a plaque from his Alma Mater, Florida State University. His flight suit featured



Inside the Mission Control Centre at Kaliningrad during the tracking of an earlier Soyuz spacecraft.

the Deputy Director of the Shuttle-Mir programme described the events as "definitely historic".

Thagard's wife Kirby and his three sons were in the control room. She said that Thagard seemed to be enjoying himself.

Controllers had to ask the happy cosmonauts to calm down at one stage but as the complex passed out of radio range the laughter could still be heard. Thagard's reserve, Bonnie Dunbar allowed that this was the time the Russians traditionally celebrated after a safe docking.

About 10 hours after Thagard floated into the station he took a radio call from one of his previous space commanders, Stephen Oswald, who was also in space aboard the American orbiter Endeavour which was performing the STS-67/Astro-2 mission.

Oswald wished Thagard well and asked what his initial impressions were of the Mir complex.

"It's not bad at all," Thagard said. "It's nice and roomy, and places that are cool and places that are rather warm so you can migrate to wherever is most comfortable."

Thagard added: "I figured if we were ever in orbit again we'd probably be on the same spacecraft. I guess I was wrong." The two flew together on STS-42/IML-1 in January 1992 on the orbiter Discovery.

"I think the fact that we've got 13

patches of NASA and the mission.

Thagard described his medical state during the early part of the mission: "I feel very well. In fact, in terms of space motion sickness, this has been the best of any previous space flight....I never did experience it this time."

When asked about any unexpected events Thagard replied that he had encountered no surprises although the interior of the Mir base block "has the look of someone's utility room. It's obviously been lived in and worked in for nine years, but apart from that it's pretty much as I expected."

He described the day as the first "halfway" busy one they had experienced on the station.

The cosmonauts also described minor irritants which had cropped up such as items which had been labelled incorrectly and an experiment which was to have used two-sided velcro which had been discarded. Thagard had to rig the experiment (SAMS) in a makeshift way to the walls of the base block.

Thagard said that the documentation of equipment was not as strict as that employed on the shuttle.

Delayed Return Likely

The Mir-18 crew was expected to return to Florida in June but a delay to the launch of the Spektr module was to delay that event. Managers saw no sense in bringing home the two Russians who had trained to reposition the Kristall solar arrays before that task was done and recent history shows a willingness on the part of managers to prolong stays on Mir to accomplish tasks.

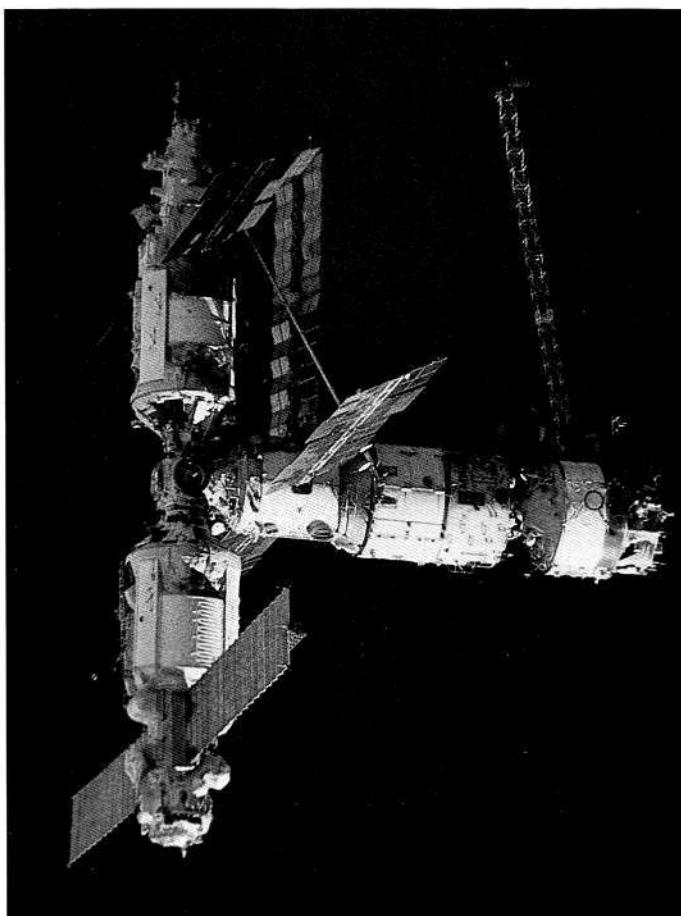
Thagard said that he was prepared to wait in orbit with Dezhurov and Strekalov for Spektr and Atlantis to arrive, probably repeating some of his experiments. Provision was made for the crew to return home in the Soyuz TM-21 descent cabin in August if the American orbiter failed to arrive.

Space flight duration record holder Valeri Polyakov declared that he was ready to come back to Earth at the end of his marathon voyage.

Speaking about the cooperative aspect Dr. Polyakov said, "We're already solving problems together. It's easier to think up here...We don't have to worry about those crazy wars."

Soyuz TM-20 Returns to Earth

The cosmonauts spent several hours on 21 March stowing equipment



In this configuration, Mir has three modules docked to the core: the Kristall module at the lowest end, the Kvant module on the right connected to the base module and the Kvant-2 module at the uppermost end. The orientation of the photo is such that the position of the modules corresponds with the diagram on p.186.

NPO-ENERGIYA for ESA

and experimental samples in the Soyuz TM-20 descent cabin in readiness for the return to Earth.

The Russian Federal Air and Space Search and Rescue Department was also preparing for the return. They had set up a search and rescue centre at the scheduled landing site 36 km from the town of Arkalyk in Kazakhstan with 4 aeroplanes, 12 helicopters and 3 search and rescue ground vehicles. A small portable medical hospital was also ready to be set up. The recovery teams expected Polyakov to be the weakest member of the crew due to his extreme exposure to spaceflight conditions.

The three cosmonauts of the Vityazi team - Viktorenko, Kondakova and Polyakov - entered the Soyuz TM-20 capsule shortly after 2100 GMT on 21 March and the hatch was closed about half an hour later. They took with them more than 50 kg of film, the results of their experiments.

About three hours later, Soyuz TM-21 undocked and began its journey home. The deorbit burn took place at about 0308 GMT and initiated the capsule's descent through the atmosphere.

The descent cabin touched down about 55 km northeast of the Kazakh town of Arkalyk at 0404 GMT on a snow-covered steppe.

After about an hour the cosmonauts

were helped out of the cabin and into lounge chairs. Polyakov insisted on walking the few steps to the chair before answering questions from reporters. The recovery crews then carried the chairs to the small tent hospital they had erected where initial medical checks were performed.

The three cosmonauts felt well upon arrival at Star City some hours after the landing. They were flown directly to the training centre from Arkalyk.

Physicians reported that the three were not feeling "any worse than the doctors were expecting". However, only their close relatives were able to speak to them, and then only through a glass partition because of their weakened immune systems.

Mars Mission Test

Polyakov's flight had lasted 437 days 18 hours 1 minute and Viktorenko and Kondakova's 169 days 5 hours 22 minutes. Polyakov and Kondakova's durations were absolute world records.

On 27 March in the first press conference since his return to Earth Polyakov said that it was vitally important that the Russians continued

their human space programme. He said to give up the programme would be a crime.

His mission had proved that the human organism could survive a trip to Mars. He cited the fact that he could walk to his chair following the landing as proof that explorers could perform tasks as soon as they landed on the surface of the planet.

However, the 52-year-old doctor did admit to some problems during the mission: "Skin came off the soles of my feet twice during the flight, and my feet became (as soft) as those of an infant", he said.

Lucid Named for Mir

On 30 March, NASA officially named Shannon Lucid, a four-time veteran of space shuttle missions to become the second American to make a long-duration flight on Mir. The announcement also said that the third American to stay on Mir would be Jerry M. Linenger.

Although originally scheduled for launch with the Mir-21 crew on Christmas Day 1995 from Baikonur, Lucid will be delivered to the Mir Station, for a 5 month stay, on the orbiter Atlantis on the STS-76 docking mission currently scheduled for April 1996. Lucid and her back-up John Blaha have been training at Star City since February. Linenger and his back-up, Scott Parazynski, will begin their training in late May.

NEVILLE KIDGER

Russian Space Shuttle

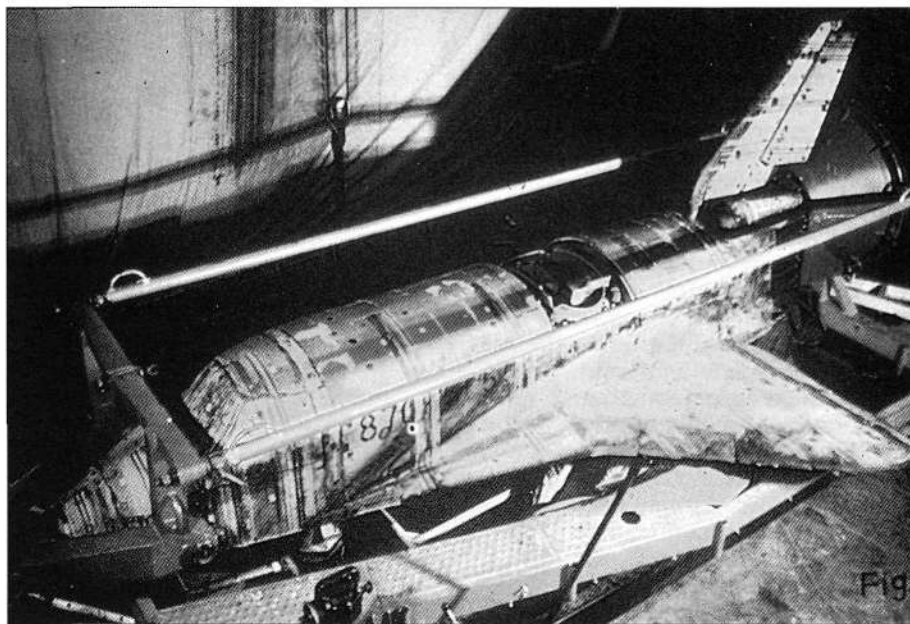
Until quite recently, the extent of the Soviet space shuttle programme eluded the watchful eyes of Western intelligence. Although actively pursued since the 1960s, it was not until 1982 that hard evidence was forthcoming to be supported later by the launch of the Buran space shuttle in November 1988.

Part 2 of this article looks at Soviet work from the 1960s to the 1980s and points to a second space shuttle programme that did not reach fruition. The programme shows all the signs of having been a military one for a space fighter capable of intercepting the US space shuttle.

Secret Revealed

It was a quarter hour past daybreak in the south Indian Ocean, about 560 km south of the Cocos Islands off Sumatra. A seven-ship flotilla, flying the red-and-gold Soviet flag, were in the process of recovering Cosmos 1374, an Earth satellite that had parachuted into the rolling blue waters just minutes before. With frogmen successfully roping the partially submerged spacecraft, the recovery ship Yamal used its freight crane to lift the vehicle on to its deck. There were men on the decks of the flotilla with binoculars, sweeping the sky, hoping that they would not find what they were looking for.

Then they heard the noisy drone of the four turboprop engines of a Royal



The BOR-5 sub-scale flight model in its transport cradle. BOR-5 was used on several suborbital missions to test flight control parameters in anticipation of the actual Buran space shuttle launching. BOR-5 was an 1/8th scale vehicle. The last BOR-5 mission was on 22 June 1988.

TIM LINDER

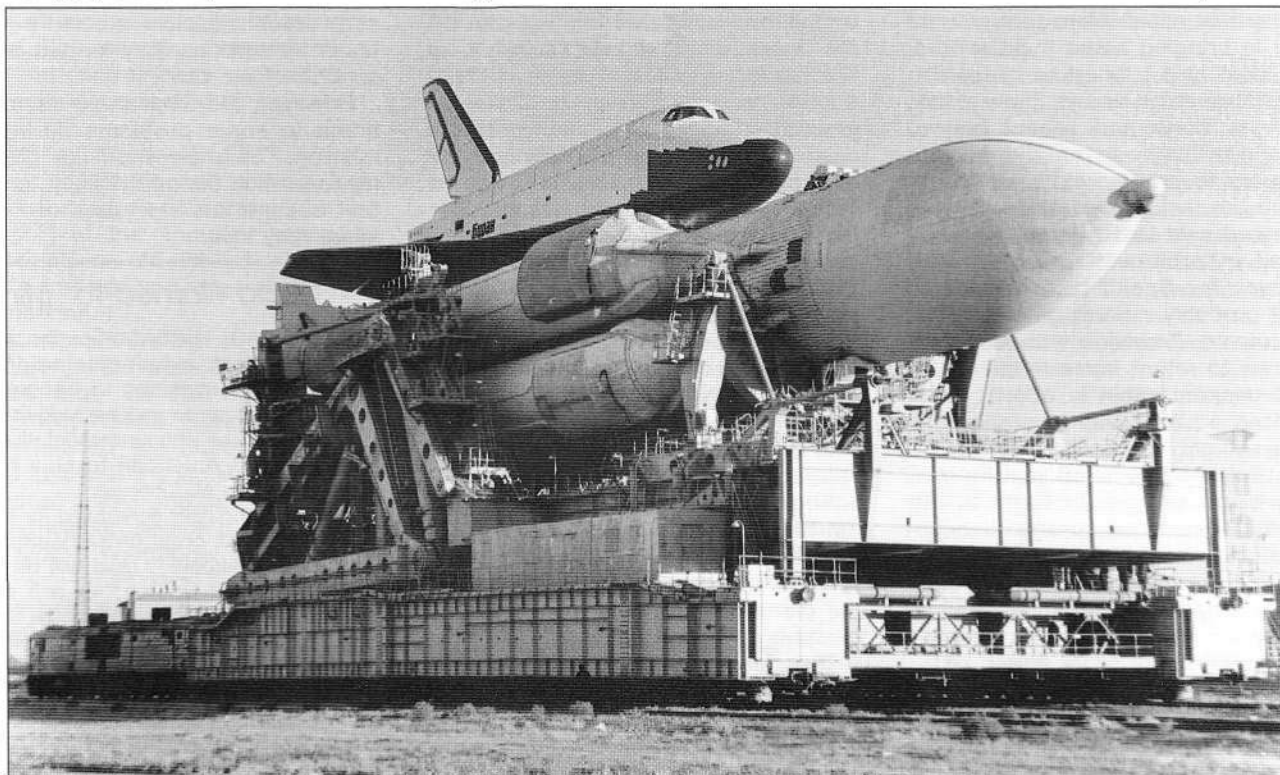
Australian Air Force Orion P-3 maritime reconnaissance aircraft. It rumbled over the horizon, darted low over the deck of the Yamal, then flew off into the distance and banked to turn around to conduct another pass. Aboard the aircraft were ten men of the RAAF 10th Squadron, whose role was to observe and image any activity aboard the Soviet ships. The date was 3 June 1982. The secret mission:

to photograph clear-cut evidence of Russian efforts to develop a winged space vehicle. The subsequent pictures showed the quick dismantling of the space shuttle-like craft while other sailors on the deck rubber-necked at the Orion flying low overhead.

A week after the Indian Ocean recovery, with press reports around the world stating that the USSR had a space shuttle, reporters in Moscow

The Buran space shuttle attached to its Energiya super booster being transported to the launch pad at Baikonur in preparation for its launch in November 1988. Activities for launch often begin early in the morning, hence the low sun angle. The railway transport/erection system seen here is the largest in the world.

A. MOKLESOVA/NOVOSTI



Projects, 1957-1994 - Part 2

BY PETER PESAVENTO

California, USA

buttonholed Alexei Leonov, a famous retired cosmonaut known for his pioneering spacewalk in 1965. The journalists asked him if the Soviet Union had tested a space shuttle the week before. Leonov's reaction was typically Russian (as reported by Reuters): "Grinning broadly, he replied, 'Indeed, last Friday a regular experimental sputnik of the Cosmos series was launched.' He would not elaborate."

In the public realm, the recovery of Cosmos 1374 was the first time that the West had hard evidence of a Soviet shuttle programme. But in the secret technocracy of the USSR, the Australians' unwelcome intrusion was only an ephemeral window on a large, multi-faceted effort to bring to fruition a Defence Ministry mandate for crewed winged spacecraft.

"Hurricane": The Shuttle Killer Enigma

One of the enduring mysteries of the Cold War has been the hidden history of a space interceptor that many Western space analysts suspect was brought to fruition in the mid-1980s. During the Reagan and Bush years, the US Pentagon issued the annual report *Soviet Military Power*, which contained a section on Russian space capabilities. Between 1983 and 1988, the annual reports discussed the development of a space plane one-fourth the size of the US Space Shuttle, that the Pentagon said was "a different program than [the project that resulted in Buran] ... This small, manned spacecraft could be used for quick-reaction real-time reconnaissance missions, space station defense, satellite inspection and if necessary, negation." The Pentagon reports predicted it would become operational in the late 1980s.

But the foretold space plane missions never took place. In their stead, Russian commentators vehemently denied that such a project existed. Indeed, in many on-the-record discussions with Russian aerospace engineers by their Western counterparts, inquiries on this topic have resulted in exasperated denials, and with the response that the idea of such a vehicle or mission was ever planned was complete nonsense. A typical response is that of Alexander Velovich, a Russian aerospace analyst based in Moscow: "There was no such space fighter. Yes, it is true that the Soviet government was worried about the US Space Shuttle attacking Moscow. But their response was to build the Buran [for the same purposes]. And cosmo-



A view of the Cosmos 1374 recovery showing the spaceplane being moved on the deck of its recovery ship on 3 June 1982 (photo processed on 4 June).

WING CMDR N. COOPER/ROYAL AUSTRALIAN AIR FORCE (RAAF BASE WILLIAMS, AUSTRALIA)

nauts only trained to fly Buran, not for any space plane. There is no truth to any of it."

But on closer scrutiny, the evidence yields a different story. Great effort had been expended in the 1960s by the Chalomei, MiG, and Sukhoi bureaus to develop a space interceptor, and the MiG bureau's concept was even revived in 1972 after being suspended in 1969. When flights of the subsonic crewed analogue for project Spiral began in 1976, it was not cosmonauts who were the pilots - but instead, Ministry of Aviation and Red Air Force personnel. Chalomei's late 1970s challenge to the Buran project is also indicative that the space plane idea had its adherents in the Defence Ministry.

In 1974, a major restructuring of design bureaus took place. Korolev's OKB-1 was folded into a new enterprise called NPO Energiya, headed by his former arch rival Valentin Glushko. On his first day as head, Glushko suspended the manned lunar landing project, and commenced a design study for a reusable orbital spacecraft. The project, nicknamed Glushkolyot ("Glushko's flier") as well as Truphoplan ("Truphanov's Plane", named after the project engineer who oversaw the main parts of the design) was to have been launched pick-a-back on a heavy lift rocket. Its unique design features would come into play after reentry into the Earth's atmosphere - it would perform a controlled descent and employ a parachute-assisted landing on skis, with soft-landing engines performing the final touchdown. The soft-landing system was patterned after the parachute deceleration systems widely used by Soviet assault troops for pin-point landings of artillery and tanks. But due to difficulties in devising a suitable, easy-to-build launcher, the Glushkolyot project apparently was abandoned in May 1976



Another photograph processed on 6 June 1982 of the recovery of Cosmos 1374. Of special note is the rear of the spacecraft, showing no evidence of thruster burns but a water hose is nevertheless cooling off that section of the spaceplane.

WING CMDR N. COOPER/
ROYAL AUSTRALIAN AIR FORCE
(RAAF BASE WILLIAMS, AUSTRALIA)

in favour of the development of the Buran ("Snowstorm") shuttle.

In the early 1970s, when plans for the US Space Shuttle Program became known, Russian fears grew that the spacecraft would be used to "zoom down on Moscow any minute, blast it to smithereens, and fly away," according to Yaroslav Golovanov, Russia's premier space historian. In late February 1976 the Politburo signed a secret decree authorizing the development of the Buran space shuttle. Ten flight-ready craft were slated to be built with a planned schedule of ten flights annually being launched aboard a new heavy-lift rocket called Energiya ("Energy"). According to Golovanov, the Soviet military viewed the spacecraft as an anticipated quick-response weapon (in the event of an interna-

tional crisis), although Western analysts suspect that another shuttle project was also begun at this time that was more apropos.

In the early 1980s, prior to any official Soviet announcements about any space shuttle project being worked on, European analysts began to hear stories that two winged space vehicle projects had been given official sanction and that the projects' names were known - for the US Space Shuttle-sized craft, "Buran"; for the smaller space plane, "Uragan" ("Hurricane").

Then four Earth-orbital missions of a winged space vehicle were flown between June 1982 and December 1984 under the Cosmos designation - two of the missions had their water recoveries in the Indian Ocean photographed by RAAF planes. Two facts pointed to their military character: successful Earth-orbital missions designated by the Russians with the "Cosmos" nomenclature are usually (but not always) military in character; and the launch site Kapustin Yar (near Volgograd) is well known as a military missile testing center. At the time of the missions, the Russians refused to confirm that the vehicles were space planes. Only after the successful uncrewed Buran mission in November 1988 did Russian officials state that Cosmoses 1374, 1445, 1517 and 1614 tested heat-shield elements and guidance systems as precursors to the actual flight of the Buran craft.

But Russian commentators neglected to point out that the shape of the sub-scale space planes did not look anything like the Buran shuttle, and in fact looked very similar in body contours to the cancelled MiG sub-

sonic crewed "Article 105.11" of the Spiral space interceptor project. To heighten Western analysts' suspicions that the four sub-scale tests did not have anything to do with the Buran programme, the Russians launched between 1983 and 1988 six suborbital reentry tests of an 1/8th scale model of Buran (called BOR-5) - including one in June 1988, just five months before the actual launching of Buran in November. The Russians did attempt to confuse the issue further by stating that the early 1980s Cosmos missions were of a craft called BOR-4, a labelling that linked the Cosmos and sub-scale Buran analogues by a number sequence.

However, in the late 1980s and early 1990s, as the Soviet government allowed more contacts to take place between the Russian aerospace industry and their Western counterparts, more details emerged about this strongly denied project. In May 1990, as part of an official exchange programme between US and Russian aerospace industries, an American delegation visited aerospace centres in both Moscow and Kiev. Among the members of the US delegation was Richard Ward, a noted international technology analyst based with Lockheed. The delegation met with representatives of the then-Soviet Ministry of Aviation, several aviation design bureaus (including MiG, Ilyushin, Sukhoi, and Antonov), the Moscow Aviation Institute, TsAGI (Tsentral'ny Aero Gidrodinamicheski Institut, or "Central Aero and Hydrodynamics Institute") and TsIAM (Tsentral'nyi Institut Aviatzionnovo Motorstroeniya, or "Central Aero-engine Institute").

In private discussions with Russian engineers, Ward was told the story of the 1980s space fighter. The Cosmos sub-scale space plane missions of the early 1980s served as a test series for the full scale interceptor. The operational spacecraft was to have had a crew of two and would have been armed with a recoilless gun for on-orbit attacks. The fighter was to have been launched aboard the Zenit ("Zenith") rocket, which began flight tests in 1985. Ward was told that the project was given impetus after the US announcement that military mission Shuttle launches from Vandenberg were slated to begin in the Autumn of 1986. The Shuttle launches from Vandenberg would have been put into polar orbits, making the entire land mass of the USSR vulnerable to nuclear bomb attacks from space.

Following the Challenger tragedy, the US Air Force decided against manned military shuttle missions, and the Vandenberg facility was shut down in April 1988 and subsequently partially dismantled. Because the polar orbit missions of a Shuttle were cancelled, the Russians told Ward that there was no longer a need for a space fighter to destroy US Shuttles, and so the project was quietly closed down. According to Rex Hall, an analyst based in London, this action apparently took place in 1987, as he has been able to identify five Red Air Force pilots who had been training for a shuttle mission and were transferred to the Mir space station programme.

What has not been revealed up to now was which design bureau or bureau had been involved in the development of the 1980s space fighter.

A photograph of the satellite Cosmos 1445 prior to its retrieval on 15 March 1983 in the south Indian Ocean. Of special interest are the recovery location aids - one on the top side of the spacecraft itself and the other in the water ahead of the vehicle (almost like a bobbin used in fishing). Also of note are the sooty appearance of the rear side of the spaceplane and its national markings (stripes and "CCCP").

KEN LLEWELYN/ROYAL AUSTRALIAN AIR FORCE



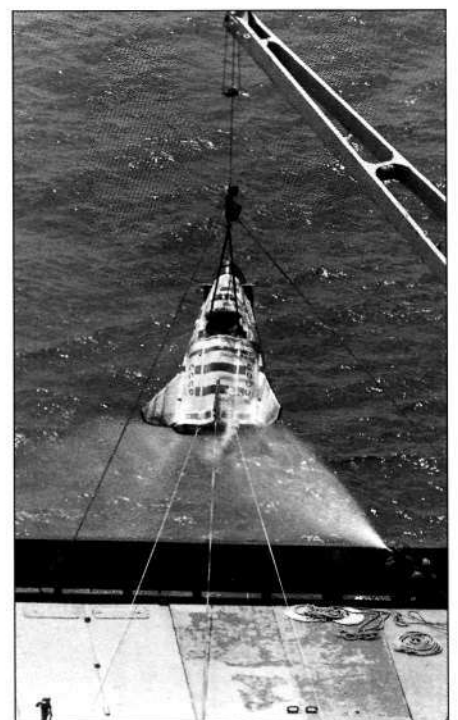
A photograph from the Cosmos 1445 space plane retrieval in March 1983. Of special interest is the profile of the space plane - it is remarkably similar to the Article 105.11, the analogue used in subsonic flights for the space interceptor programme Spiral. Western analysts believe that Cosmos 1445 (and 1374) were missions testing for a space fighter to shoot down the US space shuttle.

KEN LLEWELYN/ROYAL AUSTRALIAN AIR FORCE



Another view of the Cosmos 1445 spacecraft, here shown having its rear being hoisted down. The national markings (stripes and "CCCP") are quite evident here.

KEN LLEWELYN/ROYAL AUSTRALIAN AIR FORCE



Many Western analysts point to probable joint efforts of MiG, as well as NPO Molniya, where Gleb Lozino-Lozinskiy became head after working on MiG's Spiral interceptor project of the 1960s and 1970s. Indeed, Lozino-Lozinskiy may have accidentally revealed the connection when in a published interview in 1990 discussing the newest space plane development called MAKS, he said: "We've [meaning NPO Molniya] already tested the prototype of the [MAKS] orbiter—it was this scaled test model that had four flights - Cosmos 1374, 1445, 1517, and 1614."

One more question remains: had there been any actual launches of the full-scale version of the Uragan space plane? Western analysts point to two still-mysterious launches in Russia's Cosmos series that took place in August 1987. On 1 and 28 August, Cosmos 1871 and 1873 were launched into Earth orbit. Although the two satellites' payload masses - 10 tons - fit what the expected full-scale space plane's weight was to be, the satellites were allowed to decay naturally back into the atmosphere. No effort was made to have a controlled return to Soviet soil, and there were no on-orbit manoeuvrings. Space analysts think that the satellites were only full-scale size and weight mock-ups, indicating that there was no densely-packed test instrumentation on board.

But this brings up more questions - why only mock-ups? Why, after having four actual sub-scale orbital flights between June 1982 and December 1984 that had controlled reentries and landings, would the full-scale version not be planned to be recovered? Western analysts have a number of theories. One is that the Soviets were conducting tests and measurements before the mock-up reached orbit - perhaps they were making sure that the shuttle craft would separate properly from its booster, or - if a protective nose-shroud fairing was used over the shuttle - that the fairing was successfully jettisoned.

And there has been a more mundane explanation - that the Russian aerospace engineers were informed that the programme was going to be cancelled, and that they merely wanted to get two launches off using available materials on hand (the mock-ups) before the roubles for the project ran out. But no one really knows, as the Russians have not talked about these two Cosmos launches. According to analyst Phil Clark of the Molniya Space Consultancy in Heston, England, "The jury is still out on these Cosmos launches. No Russian source has spoken about them. I feel that this means we are dealing with a military project, and the best explanation to fit the facts presently is that these were mini-shuttle tests."

(Part 3 of this four-part series is to appear in a forthcoming issue.)



As the RAAF airplane flew over the deck of the recovery ship *Yamal* (used for the second time to retrieve a space plane), the cameraman got a good view of the faces of the Russians looking up at the aircraft. One of the men is using a tool to remove one of the heat shielding tiles on the spacecraft.

KEN LLEWELYN/ROYAL AUSTRALIAN AIR FORCE

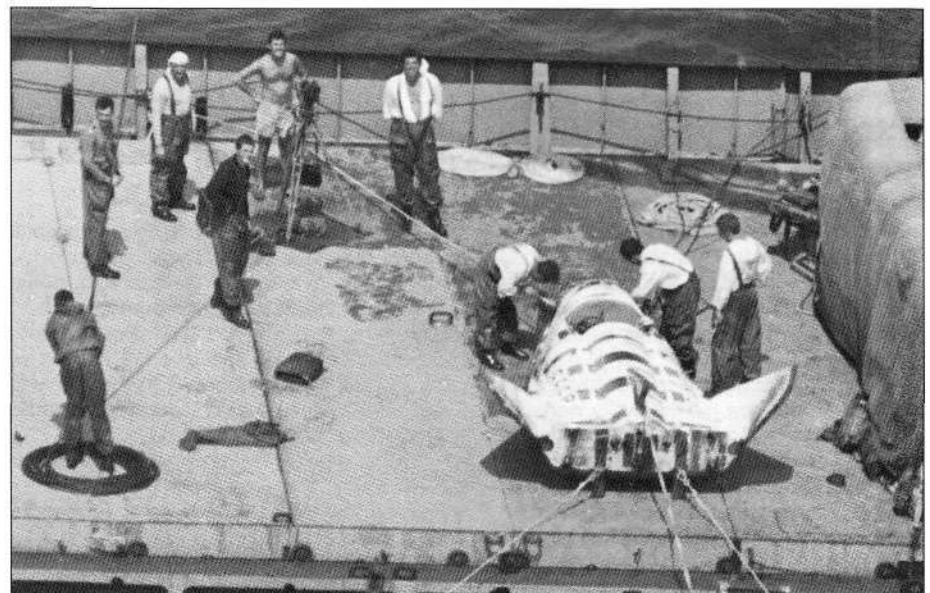


A photograph of the recovery of Cosmos 1445 in March 1983 in the south Indian Ocean. This low pass by an RAAF maritime reconnaissance aircraft shows the front view of the space plane, showing the "cockpit".

KEN LLEWELYN/ROYAL AUSTRALIAN AIR FORCE

A back view of the spacecraft Cosmos 1445 during the recovery effort. Of special note is the clear views of the men on board the ship and the burn marks on the fins of the space plane, as well as the "sooty" appearance of the rear of the spacecraft.

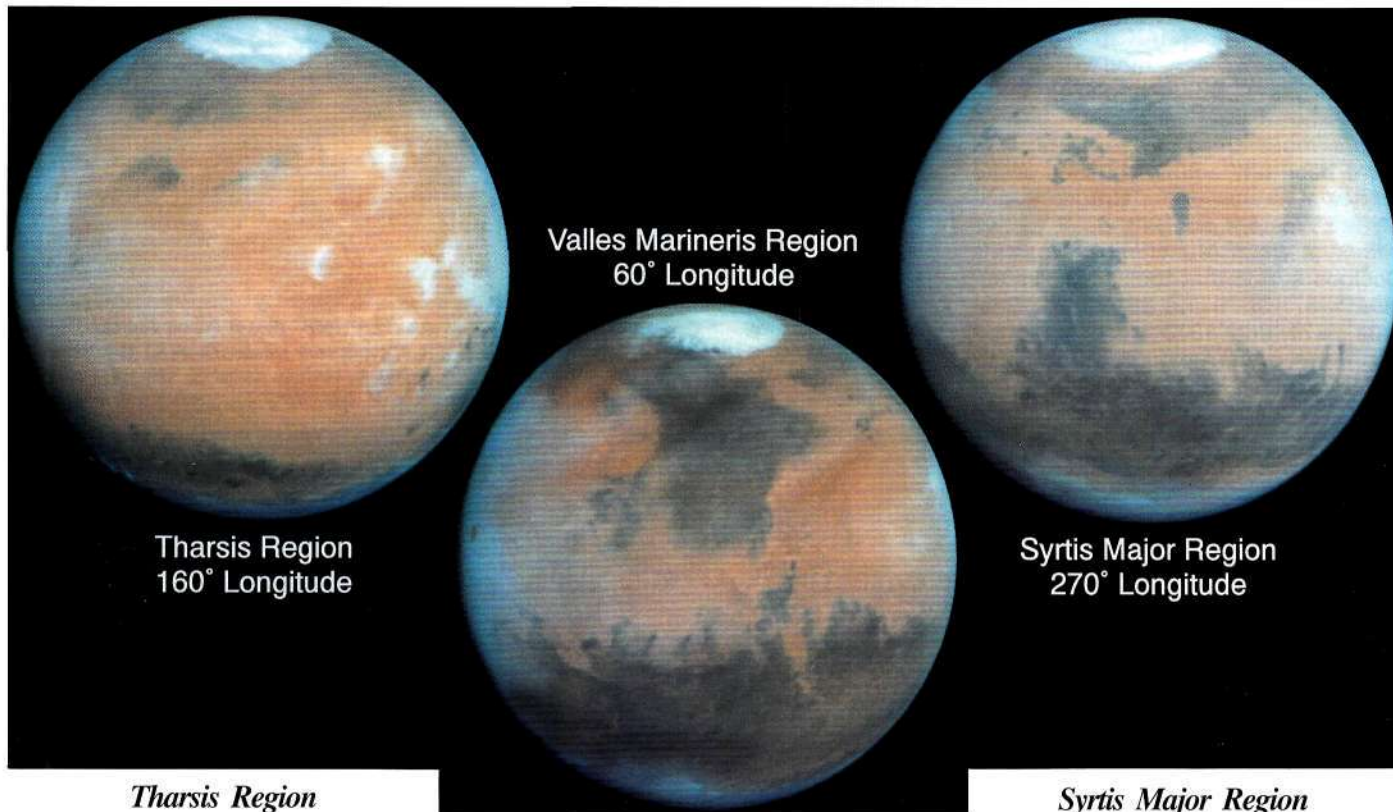
KEN LLEWELYN/ROYAL AUSTRALIAN AIR FORCE



Mars at Opposition

These NASA Hubble Space Telescope views provide the most detailed complete global coverage of the planet Mars ever seen from Earth. The pictures were taken on 25 February 1995 when Mars was at a distance of 103 million km.

To the surprise of researchers, Mars is cloudier than seen in previous years. This means that the planet is cooler and drier, because water vapour in the atmosphere freezes out to form ice-crystal clouds. Hubble resolves Martian surface features such as impact craters and other features as small as 50 km across.



Tharsis Region

A crescent-shaped cloud just right of centre identifies the immense shield volcano Olympus Mons, which is 550 km across at its base. Warm afternoon air pushed up over the summit forms ice-crystal clouds downwind from the volcano. Farther to the east (right) a line of clouds forms over a row of three extinct volcanoes which are from north to south: Ascraeus Mons, Pavonis Mons, Arsia Mons. It is part of an unusual, recurring "W"-shaped cloud formation that once mystified earlier ground-based observers.

Valles Marineris Region

The 25 km-high volcano Ascraeus Mons pokes through the cloud deck along the western (left) limb of the planet. Other interesting geologic features include (lower left) Valles Marineris, an immense rift valley the length of the continental United States. Near the image centre lies the Chryse basin made up of cratered and chaotic terrain. The oval-looking Argyre impact basin (bottom) appears white due to clouds or frost.

Syrtis Major Region

The dark "shark fin" feature left of centre is Syrtis Major. Below it the giant impact basin Hellas. Clouds cover several great volcanoes in the Elysium region near the eastern (right) limb. Past dust storms in Mars' southern hemisphere have scoured the plains of fine light dust and transported the dust northward. This leaves behind a relatively coarser, and less reflective sand in, predominantly, the southern hemisphere.

PHILIP JAMES (University of Toledo), STEVEN LEE (University of Colorado) and NASA

Venus Cloud Tops Viewed by Hubble

This is a NASA Hubble Space Telescope UV image of Venus taken on 24 January 1995, when Venus was at a distance of 113.6 km from Earth.

Venus is covered with clouds made of sulphuric acid, rather than the water-vapour clouds found on Earth. These clouds permanently shroud Venus' volcanic surface, which has been radar mapped by spacecraft and from Earth-based telescopes.

At UV wavelengths cloud patterns become distinctive. In particular, a horizontal "Y"-shaped cloud feature is visible near the equator. Similar features were seen from Mariner 10, Pioneer Venus, and Galileo spacecraft. This global feature might indicate atmospheric waves, analogous to high and low pressure cells on Earth. Bright clouds toward Venus' poles

appear to follow latitude lines.

The polar regions are bright, possibly showing a haze of small particles overlying the main clouds. The dark regions show the location of enhanced sulphur dioxide near the cloud tops. From previous missions, such features are known to travel east to west along with the prevailing winds, to make a complete circuit around the planet in four days.

The image was taken with the Wide Field Planetary Camera-2, in PC mode. False colour has been used to enhance cloud features.

L. ESPOSITO (University of Colorado, Boulder) and NASA



Ten Years of Mars Missions

The JPL Mars Exploration Office was established in July 1994 in response to NASA's initiative to scale back the cost and development time of space flight missions and to begin a sustained programme of Mars exploration. The first two missions of the Mars Exploration Program got underway last year and are the Mars Global Surveyor, an orbiter that will arrive at Mars in September 1997 and the Mars Pathfinder lander and rover, which will land on the planet and place the first robotic rover on the surface in July of the same year.

Mars Global Surveyor got off to a good start in July 1994 with the selection of Martin Marietta Technologies to build the spacecraft. Development is on a fast track schedule with built-in performance measurement to assure on-time readiness for launch in just 28 months from the time the contractor was named last year. On average, the development of planetary spacecraft in the past has been about 66 months.

The Surveyor will be a polar-orbiting spacecraft designed to provide global maps of surface topography, distribution of minerals and monitoring of global weather. The spacecraft, which will be launched from a Delta II launch vehicle, will carry six of the eight scientific instruments carried aboard the Mars Observer spacecraft. The mission will rely on an aerobraking technique - developed during the final days of the Magellan mission - that will provide a means of minimising the amount of fuel necessary to lower it into a low-altitude mapping orbit over Mars.

Mars Pathfinder, which has a cost cap of \$150 million, has reported excellent progress in all aspects of development during 1994. International participation will be a cornerstone of all new missions to Mars, and each pair of spacecraft launched during the next decade will build

Clear Weather on Mars

BY PATRICK MOORE

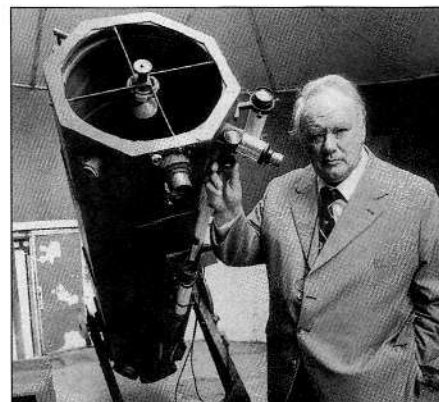
BIS Fellow

Few people doubt that Mars will be the first world to be reached by man, following the Moon. And at least conditions there are not overwhelmingly hostile; there are no sulphuric acid clouds, for example, as on Venus.

Searches for life on Mars have so far proved to be negative; the Viking landers of the 1970s found no definite traces of organic activity, though admittedly there is something rather odd about Martian chemistry. However, we have looked in only two sites (Chryse and Utopia) and it is premature to dismiss Mars as completely sterile, though the evidence does point that way.

The last probe, Mars Observer, failed; its fate will never be known. But in the meantime observations have been carried out from the Hubble Space Telescope, and the results have been surprising. The climate has changed markedly since the Viking landings. The temperature has dropped, the atmosphere is clearer, and there is no ozone hole. Hubble has shown ice-crystal clouds, but no dust storms, and it seems to be the lack of dust in the atmosphere which has caused the change.

on the experience of its predecessors. For instance, landers in future years - 1998, 2001, 2003 and 2005 - will capitalise on the experience of the Mars Pathfinder lander mission. By the same token, progressively smaller, streamlined orbiters will allow smaller and less expensive launch vehicles to be used as NASA's armada of spacecraft is readied to explore and act as data relay stations for international missions of the future. ■



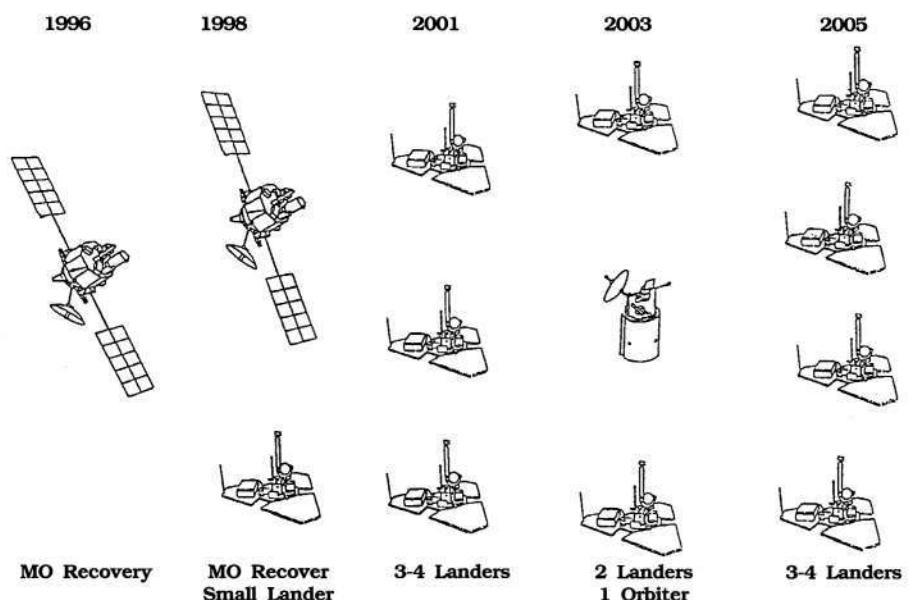
Martian dust-storms can be global, and there are times when the surface features are completely hidden - as they were in 1971, when Mariner 9 approached the planet; only the tops of the Tharsis volcanoes poked out. (At that time I was using the Innes 27-inch refractor in Johannesburg specifically to monitor Mars and report to the US; for some nights the disk looked featureless.) Dust-storms tend to occur when Mars is near perihelion. During the current opposition Mars has been not far from aphelion, and of course its orbit is much less circular than ours, so that major dust-storms would not be expected, but they have been infrequent during the past decade, and this means less general atmospheric dust to warm the thin 'air'.

It is not at all likely that this is significant. No doubt Mars, like the Earth, experiences definite long-term changes in climate, and before long we may expect dust-storms to return, but we do want to know whether there has been a major change at an earlier stage. The great volcanoes must once have been active; there is clear evidence of the past existence of running water and even flash-floods. How long is it since activity of this kind ceased - and can we be sure that the volcanoes are really extinct? Did life begin on Mars, only to die out when conditions became less favourable?

What we need, of course, is a sample-and-return mission, and there is no reason why this should not become possible in the very near future. Only when we can analyse Martian material in our laboratories will we really know the answers. (Of course, some authorities claim that this has already been done, and that some meteorites found in Antarctica come from Mars; I admit to being sceptical, but I may be wrong!).

Mars is still on view, and though opposition is well past it is still easy enough to see some surface details with a modest telescope. But for greater resolution we rely on Hubble - and at least we can be confident in saying that the weather on Mars is clear and very, very cold! ■

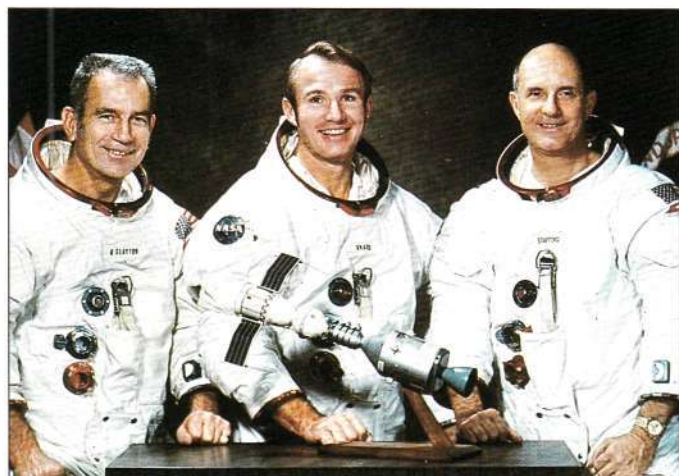
Mars Surveyor Program Elements



(Diagram supplied courtesy Theo Pirard)

An Historic Hand-

Apollo-Soyuz Test Proj



The American crew was named on 30 January 1973 and included Deke Slayton (left), one of the "Original Seven" astronauts who had been grounded because of an irregular heartbeat just before his Delta-7 Mercury mission in 1962. The other crew members were Gemini and Apollo-veteran Tom Stafford (right) and former Lockheed test pilot Vance Brand.



The Soviet crew was presented at the Paris Air Show on 24 May 1973 and consisted of the USSR's first spacewalker Alexei Leonov (right) and flight engineer Valery Kubasov. It was the first time the Soviet Union announced the names of a crew before they had flown.

One of the biggest problems during training proved to be the language barrier. It was agreed that each crew would speak the other crew's language during direct communications between the two spacecraft. Here Vance Brand (centre) and support astronaut Bob Overmyer can be seen studying Russian.

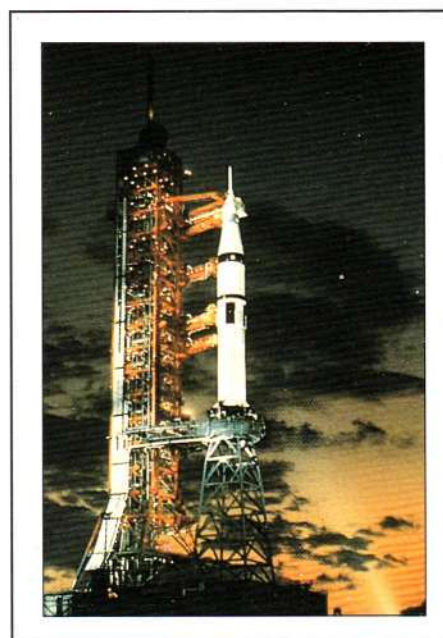


If all goes well, we shall soon be seeing the historic first docking of the US Space Shuttle Atlantis to the Russian space station Mir. Appropriately, this space spectacular will occur close on twenty years after the equally historic docking in space between an American Apollo and a Soviet Soyuz on 17 July 1975 when for the first and, thus far, only time two manned spacecraft from different countries docked in orbit. We now look back at that first step towards international cooperation in space which is seen as the forerunner of the present mission and of the many more hand-shakes in space to come.



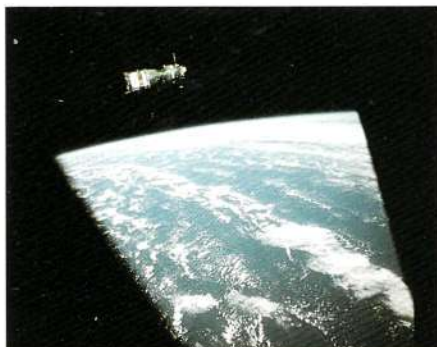
As in the case of the Shuttle-Mir docking, the Americans did the chasing during ASTP and so the Soyuz was launched first. It lifted off from Baikonur on 15 July 1975 at 5:20 pm local time.

Seven and a half hours later and 16,000 km away, the Apollo was launched from the Kennedy Space Center on a Saturn-1B rocket at 3:50 pm local time to begin the catch-up journey towards the orbiting Soyuz.



Hand-Shake in Space

Project Remembered



At about 8 am Houston time on 17 July, Vance Brand reported: "We've got the Soyuz in the sextant". Hard dock between the two craft was accomplished over the Atlantic Ocean at 11:09 am. "Soyuz and Apollo are shaking hands now", radioed Leonov.
(See left)

All photos: NASA



The Apollo-Soyuz Test Project (ASTP) was the result of an agreement signed by US President Nixon and his Soviet counterpart Kosygin on 24 May 1972. Initially, this agreement called for docking of an Apollo and a Soyuz to the Salyut space station, but because of practical hurdles this plan was scaled down to a less ambitious mission in which Apollo and Soyuz would be linked to each other by means of a specially designed docking module.

GREETINGS



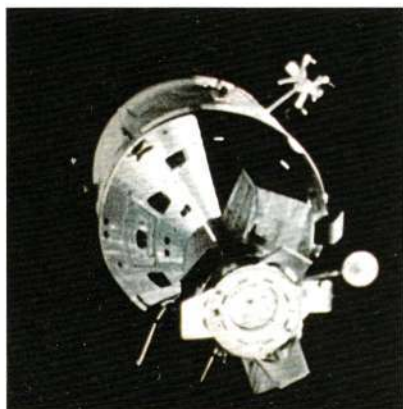
FAREWELL



Left: Three hours after docking, with the spacecraft passing over Amsterdam, the hatch between Soyuz and Apollo was opened and Stafford (left) and Leonov shook hands. "Glad to see you", said Stafford in Russian, to which Leonov replied "Very very happy to see you".

Right: Final handshakes took place at 3:49 pm Houston time on 18 July, after which both crews returned to their respective spacecraft. Vance Brand is seen in the hatch to the docking module.

Undocking took place at 7:02 am Houston time on 19 July. Apollo and Soyuz then performed station-keeping manoeuvres to photograph each other and conduct a number of experiments. After a short redocking the two craft finally separated.



Leonov and Kubasov landed in Kazakhstan on 21 July. They are seen talking to reporters shortly after leaving their Soyuz.

The final splashdown in the US manned space programme took place on 24 July, as the Apollo landed in the Pacific Ocean close to the recovery ship USS New Orleans. It would be six years before Americans again ventured into space.

After the recovery ceremonies it was learned that the crew had inhaled toxic gases from one of the steering jets, that were sucked into the cabin during descent. Fortunately, this had no serious consequences and after two weeks in an Hawaiian hospital Stafford, Brand and Slayton were released on 8 August 1975.



Woomera

Part 1: The Making of a Rocket Range

On 12 June 1970, Europa F-9 lifted off from the Woomera Rocket Range. Following the range's demise as a major launch site it became little known and virtually unremembered. Yet its history, development and utilisation provide a unique and interesting story which begins with this first part of a two-part article.

Advent of Large Rockets

In September 1944 the first German V-2 ballistic missiles fell on London. With ranges of 200 miles and payloads of over one ton, they far superseded any rocket in existence at the time. It was this weapon of destruction that launched the space age.

Before the war was even over, the Allied Chiefs of Staff had realised the potential post-war significance of the new weapon. During the massive allied invasions at the end of WW-II advancing Russian troops captured the main V-2 research and development facilities at Peenemunde and vast stocks of unfired V-2 rockets.

The American armies captured enormous stores of V-2 rockets at a facility located at Leipzig. They also captured many German scientists, including the renowned Wernher von Braun. Britain, however, the nation which suffered the heaviest bombardment of these new weapons, did not capture any major V-2 facility, store, scientist or related hardware. This appeared disastrous for the postwar defence of Britain. Like the other superpowers at the time, Britain knew that rocket technology was to be a way of conducting warfare in the future.

Realising its vulnerability to rocket attacks, Britain set about forming a deterrent. It immediately put together a crack team of scientists to regain lost ground in the race for rocket supremacy. It has been said that the planning and goals set for this crack team of scientists were sloppy and haphazard, but in the turbulent post-war environment with a virtually unknown technology, this was the same all over the world.

One of the first projects was a missile known as Hammer. The purpose of this weapon was uncertain. It appears that it would have been a British tactical weapon with a range of 200 miles, with the same accuracy (or lack thereof) as the V-2 rocket. The details of this new weapon were so vague that it could not possibly be successful. There was no foreseeable target to hit within 200 miles of Britain, certainly none as big as a city. Many projects were put forward, the most forward looking and widely supported being the missile codenamed "Menace". This would be a true Intercontinental Ballistic Missile (ICBM). Rock-

BY ISAAC GRANT BOXX

NSW, Australia

etry was a virtually unknown science at the time, and Britain had no true rocket scientists experienced in liquid rocket engines. Therefore there was much testing to be done.

Britain Needs a Test Range

Unfortunately Britain did not have any expanses of barren land over which to test such rockets, but many proposals were made to solve the problem. The idea of launchings from Aberporth, Wales was abandoned as the site was too close to the sea and the rockets had to be recovered for analysis, which would not be possible if they were to fall into the sea. There were political risks too, as it was possible that a rocket fired from this range could impact on Ireland. This could not be allowed.

Other sites around the British Commonwealth and Europe were examined. Northern Africa was considered. Its vast expanses of desert and close proximity to Europe would have made it an ideal site for a rocket range. This area was decided against as a rocket range in Northern Africa at the time would have meant co-operation with the French. Due to the political turbulence surrounding the end of WW-II, such co-operation and coordination were deemed too risky both politically and militarily.

One of the most promising ideas was to launch the new experimental rockets from Churchill, Canada. Canada was an industrialised nation at the time, thus solving the possible problems associated with supply. On further analysis however it was seen that the area in question was too cold. The range would be nearly useless in winter, due to a buildup of snow and ice which would make vehicle recovery impossible. Thus, this site was rejected.

Then it was remembered that Australia was on the map of the British Commonwealth! It was perfect. Australia had a huge amount of scarcely populated land. It was politically stable. It had land ideal for a rocket range, flat, barren, almost vegetationless. There was rarely any rain and never snow, thus making optical tracking (the most common form of track-

ing before radar was widely accepted) a simple affair. The people there were strong allies to Britain, eager to help. Other than its isolation from Europe, there seemed to be no minus points to the idea.

The idea gained momentum and in April 1946, a delegation was dispatched to Australia to examine the feasibility of a long range weapons testing range. After some preliminary studies and talks, an agreement was reached. This agreement, formally known as The Joint United Kingdom/Australia Project, stated that the two nations would build and operate a military testing range at Woomera, South Australia to test a wide range of military ordinance, ranging from ballistic missiles to new radar systems. This agreement lasted for many years.

Australia Builds Woomera

By the time Britain had made up its mind, Australia had already decided on an ideal location for the range - in the desolate expanses of South Australia. The site of the launch pads was known to Australians as Woomera. It was well away from any major centre of population, being situated several hundred kilometres northwest of Adelaide.

There is no vegetation there to speak of save for salt bush and spinefex, a spiny grass which grows in clumps. There is no water on the surface. Average temperatures reach 34 °C in summer. The rainfall averages 191 mm and evaporates at a rate far higher than this. If a man was left out there with no water, he might live for nine hours, but no longer. Obviously, there was much work to do before any rocket would leave a launch pad.

The area was almost totally unexplored territory to Europeans, and needed to be surveyed. The Australians put men to work doing this immediately.

These reconnaissance teams represented everything Australian about the project. They were rugged pioneers, moving through unexplored territory in perhaps the harshest terrain in the world. Legends sprung up about these teams.

One of the most highly regarded of these men was Len Beadell, a rugged man who could do just about anything from pulling a tooth to bulldozing a



The ELDO rocket EUROPA I stands on launcher 6A at Woomera. The launch of Europa F-9 on 12 June 1970 marked the beginning of the end of major launchings at Woomera.

new road. This man was indispensable to the Woomera range. Without this man, and other people like him, the Woomera rocket range would not have been possible. During his career, he and his team put in 6,000 km of road and made numerous geological surveys. Stories of this man were widespread and often told. The people of Woomera would look forward to the day he would return from a field trip to hear of his adventures in the desert wilderness. Now seventy years old, he is still remembered throughout Australia as a pioneer. He recently received an Adventurer of the Year award in recognition of his part in opening up the heart of Australia.

After these surveys, the Australian government formed a vehicle recovery area for the rocket range. This area became known as the Woomera Prohibited Area (WPA). This area was expanded throughout the history of the range to accommodate its projects, until it covered a total area of 264,000 km². This is a larger land mass than some small nations. After the completion of several of the long range rocket trials, this area was reduced to 130,000 km².

It was clear that a military rocket range would require several thousand technicians and scientists. These people would require water, food, housing, medical services and other human necessities. The range was not in any position to produce its own supplies, as there were virtually no such resources anywhere at or near the site. Therefore they would need to be shipped there somehow. Almost every brick, scrap of timber and bit of mortar would have to be transported out to the site. The problem was made all

the worse by happening at a time when a great deal of government resources were devoted to housing and finding jobs for returning soldiers of WWII. No politician with a clear head would do anything to interfere with the latter. Thus the range had to be built on a shoestring budget.

What was to follow was nothing less than a miracle of modern engineering. A power station was erected to supply the electricity needs. Over 100 km of railroad were connected as a spur to the massive railroad which runs across the centre of Australia. A world class telephone system was installed. To supply water for the town, a 25 cm pipeline was built to the Murray river over 600 km away. A township was erected in the middle of nowhere. Houses were built. A hospital was erected. Shops appeared. Command and communications facilities sprang up from nothing. The ingenuity which went into the construction of the town of Woomera and the range itself was truly remarkable. Problems cropped up at every turn. One such example was that much of the local terrain was gibber stone - sunbaked earth covered in sharp, slate-like rocks which would readily shred tyres, boots and feet. No building could be erected on gibber terrain before the top layer of earth had been slashed off with a bulldozer. Other problems faced included machinery breakdowns and dehydration of the workers, but eventually all were overcome to produce a world class experimentation facility.

Weapons Research Establishment (WRE)

The real power behind the Woomera rocket range lay not at the

facility itself but several hundred kilometres away in the town of Salisbury, South Australia. Whilst all launches took place at the range, the major research and industrial work was carried out at Salisbury.

Salisbury may be considered the nerve centre of the facility and listed below is a brief chronology of the major Woomera-related events of Salisbury. In 1943 at Salisbury, South Australia, the Australian government built at a cost of A£7 million (the currency used at the time) the Salisbury Explosives Factory (SEF). This complex was sprawled over 4.5 km². It contained 1200 buildings. After World War II it sat idle.

In 1947, the Australian Government formed the Long Range Weapons Establishment (LRWE) and based it at the SEF with the goal of building a massive weapons testing range.

In 1949, the LRWE facilities at Salisbury were supplemented by several other defence related laboratories. These included The Aeronautical Research Laboratories, The High Speed Aerodynamics Laboratory, The Propulsion Research Laboratory and The Electronics Research Laboratory. It was now clear that the defence research and development complex of Australia was to be firmly based at Salisbury.

In 1955, The Weapons Research Establishment (WRE) was formed. This consisted of all military research laboratories and government establishments based at Salisbury. Most of the defence-related research in Australia since WWII has been based at Woomera. Much of the Australian work done at the Woomera range was controlled by WRE.

Political Indecision

Not all of the obstacles faced in the history of the Woomera rocket range were physical. Much of the hardship faced by the programme was political.

Due to the indecision by the British, there was a great deal of political turbulence concerning the necessity of the range. In 1948, Britain cancelled its programme to build a modified British version of the V-2 ballistic missile. As a direct result of this, the Woomera rocket range itself was formally cancelled in the same year. Many high ranking officials were very concerned about the implications of this cancellation. There was fierce support for the range from many fronts and frenzied lobbying for the range by many enthusiasts, both military and civilian.

Perhaps the man most directly responsible for the saving of the range from the political axe wielders was General Evetts. His long struggles and ceaseless efforts are said to have been what saved the range from being forgotten altogether. He went straight to the top with the problem. After much tireless effort, he convinced prominent political figures of the possibilities of the range. Even so, some major cutbacks were made to the original plan. The initial grandiose plans for a massive continent spanning range were temporarily forgotten in favour of a much smaller, general purpose military ordinance testing range.

This new range would be dedicated initially to purely defensive or general purpose weapons, such as anti-aircraft missiles. Sir Henry Tizard, a prominent military/political figure at the time, was quoted by Ivan Southall in his book *Woomera* as saying, "If the range is there, it will attract work as a magnet attracts iron filings." This turned out to be a truly prophetic comment. Soon, the smaller range was approved and many experimental weapons were trialled there.

Problem of the Sheep Farmers

Not all of the political flack was external in origin either. There were two main thorns in the side of the range planners. The first of these was the pastoralists, who had lived in the area for generations. These people had rented the land on hundred year leases from the Australian government. It was naturally assumed that these leases would be readily renewed when the time came. When the range was announced, rumours began to circulate that the government was planning a massive land-grab and that the farmers would be left without homes or their sheep stations.

The sheep farmers have always been a national icon of Australia, and it was clear to the range planners that displacing them would not be tolerated. After much thought, it was decided that the pastoralists would be informed of the potential dangers of the

range, and allowed to make their own decisions on whether or not to stay in the area. No farmer is known to have chosen to leave.

There were sheep stations directly underneath the projected firing line of the range. There were homesteads within ten miles of being directly beneath the firing line. The politicians who supported the range were not naive. They realised that the accidental death of a local sheep farmer, by one of their newfangled rockets could readily spell the immediate cancellation of the rocket range. Therefore extensive precautions were taken to assure the safety of the pastoralists of the area.

A whole system of early warning of rocket firings was created. Before each live launching of any major test vehicle, six warnings were given out. Telephones were installed in each of the homesteads in the firing line for this express purpose. When the range evolved into a long range weapons research facility, it became clear that it posed a real danger to life and limb for the pastoralists. The government was so eager and concerned to prevent any mishaps to them that it built bunker-like shelters at each of the homesteads in the danger zone. Thirty of these bunkers were built at a cost of A£2000 (at the time) each. Even with all the precautions to minimise the physical risk to the local farmers, several problems still surfaced. In the early days of the range there were isolated accounts of country roads to and from the homesteads being ruined by the heavy military vehicles used by the range. Cattle gates constantly collapsed under the weight of the military trucks. Fences were reported to have been deliberately cut by rocket recovery teams in a hurry to find the spent rockets. There were even some reports of juvenile military personnel scaring flocks of sheep by chasing them in motor vehicles. To someone who makes a living by managing sheep these were heinous crimes. Fortunately, however, most of these early problems were solved with a minimum of fuss.

Problem of the Aborigines

The second major political influence in the development of the range was the welfare of the native Aborigines who had lived in the desert expanses of South Australia for thousands of years.

During the mid-twentieth century, Australia was finally beginning to understand the cultural issues and concerns of the native Aborigines. The desert regions of central Australia were, at the time, one of the last remaining areas in which the Aborigines lived in their traditional nomadic manner.

The building of the Woomera rocket range posed a serious potential threat to the Aborigines in the area. History

has shown that when a more technologically advanced civilisation meets a technologically primitive civilisation, the culture of the more primitive society is usually destroyed. To varying extents, this has happened in the settling, or colonisation, of Australia, America, the Pacific Islands and other areas.

Even if it is totally unintentional, the destruction of a culture can still occur. It was feared that the range would serve as a catalyst to the destruction of one of the few remaining indigenous cultures of Australia, even simply by allowing an increased and uncontrolled contact between the two cultures. The government was not prepared to allow this to happen. The government tried to take as many precautions against the uncontrolled interaction between the Europeans and Aborigines as it could. This was to try to assure that the Aborigines' culture was not destroyed by assimilation into a European society. The government was not proposing a total segregation of the Aborigines, but merely trying to assure that they were not harmed by contact with irresponsible people who did not understand or have regard for the culture of the Aborigines.

The Australian government set up a strict set of guidelines regarding the interactions between the Europeans and the Aborigines. These regulations included that there were to be no unescorted visits to any of the Aborigine tribes. A sexual relationship between a range employee and a local Aborigine could result in the dismissal of the employee. These are but a few of the stringent regulations put into action by the range administrators. These regulations were rigorously enforced by range officials.

One of the key figures involved in the enforcement of these regulations was Walter MacDougall. He was a man who knew and understood the Aborigines of the region and was highly respected by the local tribes. He was hired by the programme in 1947 to help assure the well-being of the Aborigines. This was a wise decision, as MacDougall was instrumental to the efforts to bring about the peaceful coexistence of the range and the Aborigines. While he tried to accommodate the needs of both, he was ruthless in his protection of the Aborigines' culture. As Southall put it, in his book *"Woomera"*, "MacDougall is an officer of the law, not without power or the courage to use it". It was largely due to the efforts of this man that there was, at least most of the time, a peaceful and amicable relationship between the range personnel and the local Aborigines.

In the second article in this series, I will attempt to paint a brief overview of the operations and achievements of this truly unique rocket range. ■

Role of Space in Preserving and Propagating Life

Space should play a role in safeguarding the biodiversity and ecological balance on Earth as well as in serving the cosmic future of Life. This article summarizes proposals that the author has made about these matters in *JBIS*, a monthly publication of the British Interplanetary Society.

* * *

Of the estimated 5 - 10 million living species up to 30%, or several million, may become extinct in the next fifty years. Recognizing this, scientists are starting to organize gene banks, where tissue samples containing the DNA of endangered species will be preserved. Realistically, this may be the only chance to preserve the genetic heritage of many species and with it the only hope that some may be eventually restored to life.

However, the genetic samples must be frozen permanently in liquid nitrogen. A short interruption due to loss of will, lack of funding, war or natural disasters, during centuries or millennia of storage, could destroy the samples. Funding for gene banks is already difficult, and given the historic record, it is doubtful whether any society can be supportive for millennia. Ideally, therefore, the irreplaceable genetic treasures should be secured in locations hard to access by saboteurs and vandals, at sites that stay at or below liquid nitrogen temperatures naturally and permanently.

No sufficiently cold and safe sites exist on Earth. However, suitable polar craters on the Moon are in permanent shade with temperatures always below 100°K. It would be relatively easy to construct a few underground genetic depositories there without adding much extra cost to future manned lunar missions. It may be possible to use relatively cheap technology even sooner to soft-land genetic payloads in these cold craters, packaged in protective cladding until later missions could transfer them to underground shelters.

Even safer longer-term depositories than lunar sites could possibly be established on satellites sent into remote cold solar orbits beyond 10 AU, or on small cold, gravitationally easily accessed icy moons of the giant planets.

Because of the microscopic nature of genetic materials, a gram of tissue, possibly transported to lunar storage for a few hundred dollars, could salvage the genetic heritage of a species.

The space depositories would need no further maintenance and be cheaper in the long run, as well as safer than Earth-based sites. Once completed, they would need to be visited again only when society is ready

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to restore the Earth as a permanent reserve for terrestrial life.

* * *

A major threat to much wildlife, as well as human habitats, health and economy, is posed by greenhouse warming as the fossil fuel economy expands. The damage may range from environmental and climatic disasters creating billions of refugees, to, in the worst case, runaway warming that could jeopardize terrestrial Life altogether.

Against such scenarios, this author, as well as Dr. James Early of Lawrence Livermore Laboratories and the Swiss scientist Dr. Walter Seifritz suggested independently about six years ago, the construction of large screens in space that would deflect some of the solar radiation from Earth and produce a compensating cooling effect. The required shading would need to intercept about 3% of the solar light, requiring a shield equivalent to a square 2,000 km on each side. It would be best constructed from forty thousand 10x10 km units of film about 0.002 mm thick, with supporting wire structures and automated positioning devices.

The shield could be at the L1 Lagrangian point, or possibly in a levitated orbit deeper in space, such as at 0.9 AU. These screen units can act as "levitated sails" and stay in non-Keplerian orbits permanently on the Sun - Earth axis, using radiation pressure to cancel part of the Sun's gravity. They could also be manoeuvred by solar sailing to maintain the desired amount of shielding. They could be constructed in space from lunar materials, shipped by mass drivers similar to those proposed by Prof. G.K. O'Neill for space colony construction.

Instead of sails, a cheaper, low-technology method might use clouds of fine lunar dust of a few microns in size at L1 or in levitated orbits. This payload could be launched, with minimal processing, in packets directly from the Moon and dispersed into the desired orbits. Whether in the form of a screen or dust, the required mass would be about ten million tons,

About the Author



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Michael Mautner was born in Budapest, Hungary, graduated in Chemistry and Physics from the Hebrew University of Jerusalem, and obtained a PhD in 1975 from the Rockefeller University in New York, where he also served on the faculty. He was a research chemist at the US National Bureau of Standards (now NIST) and is now Adjunct Associate Professor of Chemistry at the Virginia Commonwealth University. His main research interest is the physical chemistry of ions with applications to astrochemistry and biophysics. He is also a Senior Research Fellow at the Department of Chemistry, University of Canterbury and at Lincoln University, New Zealand, where he conducts experiments on extraterrestrial soil microbiology. He is the author of over 110 scientific publications.

equivalent to a modest 100 - 200 m lunar hill or asteroid.

Space-based shields could also be applied to decrease the incidence of harmful UV radiation incident on the Earth if the ozone problem becomes severe.

Of course, the space shield would be of interest only as a last resort, if conservation and reforestation fail and the greenhouse effect indeed proves catastrophic. It would become especially important if feedback effects caused runaway heating that could threaten all Life on Earth. In that case, no effort to reverse this threat would be too expensive.

* * *

Beyond safeguarding the Earth and fellow species, it is increasingly recognized that it is also the human purpose to propagate Life in the universe. This "panbiotic" or "biocosmic" objective can be based on the growing appreciation, as the intricate mechanisms of biology are revealed, of Life being a unique phenomenon in Nature, of great complexity and wonder; indeed, a phenomenon that requires a precise

coincidence of the laws of matter, which makes Life precious even in the context of the overall universe. The "panbiotic" ethics also derives from the purpose that Life itself pursues, in effect, its pursuit of self-propagation. As part of Life, it is our duty to promote this purpose.

Of course, we would prefer to spread Life in space in the human form, and can indeed hope to settle the Solar System soon. However, interstellar travel requires, at best, remote and uncertain technologies, and ethical obstacles to the launching of humans to uncertain futures. Recognizing this, we proposed that Life should be launched toward other solar systems sooner and more safely in the form of its microbial representatives, using near-future technology. Indeed, important advances in relevant technologies are now occurring. Some key advances are: precise astrometry (0.1 milliarcsec) for navigation; engineered evolution of extremophile micro-organisms for a hardy payload; advanced solar sail material and methods for propulsion and braking. Especially important is the ongoing detection of young extrasolar planetary systems. This provides targets where local life (if any) would not have emerged yet, preventing possible interference with local biota. Once landed, the microbial payload would have a good chance of survival; indeed, we found in recent experiments that micro-organisms would be able to survive on exogenous organic materials captured in meteorites and interplanetary dust particles into the environments of young planets.

Advancing technologies and an emerging panbiotic ethics suggest that within a few decades we will be ready to launch missions that will initiate evolution on dozens of nearby planetary systems. The ensuring evolution will hopefully lead to intelligent beings who will eventually propagate Life yet further into the galaxy.

Through diverse endeavours, including those summarized above, space flight can be instrumental in preserving the habitat and genetic heritage of Life on Earth and in securing its expansion in the universe. These endeavours will endow human existence with a cosmic purpose.

* * *

The above is extracted from the following *JBIS* articles: "Space-Based Genetic Cryopreservation of Endangered Species", 1995, submitted; "A Space-Based Solar Screen Against Climatic Warming", 44, 135-138 (1991); "Directed Panspermia: A Technical and Ethical Evaluation of Seeding Nearby Solar Systems", M. Meot-Ner (Mautner) and G. L. Matloff, 32, 419-423 (1979); "Directed Panspermia: 2. Technological Advances Toward Seeding Other Solar Systems, and the Foundation of Panbiotic Ethics", 1995, in press. ■

Reusable Rocketships

George Mueller Joins Kistler Aerospace

On 26 April, Kistler Aerospace Corporation, a Seattle-based company that is developing fully reusable rocketships to launch satellites into low Earth orbit, announced that Dr George Mueller, former head of the Apollo lunar landing programme has accepted the position of Chief Executive Officer. Kistler is a privately financed company that does not depend on any government funding to develop and operate its rocketship fleet.

George Mueller, who is an Honorary Fellow of the British Interplanetary Society, said "I've been advocating the development of low cost fully reusable space vehicles for many years, and I think with the advent of the latest technologies, the time has come to stop studying it to death and just do it! And that is what we are going to do. I'm hoping to have our first Kistler rocketships delivering payloads to orbit in less than four years."



George E. Mueller

In 1963, at the time the Apollo programme was in disarray, Dr Mueller was asked to come to NASA as head of the manned space flight programme, where he was responsible for the Gemini, Apollo and Saturn programmes. From the beginning of Gemini flight operations in 1963 to the second Apollo Moon landing in 1969, he directed the US manned flight programme as Associate Administrator for Manned Space Flight.

George Mueller was also the originator of Skylab, the world's first space station, and was the "Father of the Space Shuttle". He was author of the post-Apollo plan "An Integrated Program of Space Utilization and Exploration" which has been the guiding document for NASA for the past several decades.

After leaving NASA at the successful completion of the second lunar landing he continued to be active in furthering the peaceful uses of space, first as President of the American Institute of Aeronautics and Astronautics and, at present, as President of the International Academy of Astronautics. In the latter position he has led the Academy into a proactive role in furthering international cooperation in space exploration and applications. These include the development of a series of "Cosmic Studies" including



"A Case for an International Lunar Base", "Inexpensive Scientific Satellite Missions", and "The International Exploration of Mars". Another initiative that the Academy is undertaking is the creation of an International Space Exploration Institute in support of the space agencies of the world.

Kistler is the first company in the world that is currently developing fully reusable rocketships that will dramatically reduce the cost of launching payloads into space. Many technical experts do not believe that the technology is currently available to build such reusable rockets, but Walter Kistler has invented new concepts that he believes will make it possible using available technology.

During the past year Kistler Aerospace has assembled an outstanding technical team that is currently developing fully reusable subscale technology demonstration rockets. Led by Burt Rutan, who designed and built the Voyager round the world airplane and the DC-X rocket, a dozen contractors are building the demonstrator rockets which will begin flight testing later this year at Mojave, California.

James Harford Receives Award

In early May, Mr James J. Harford, who is a Fellow of the British Interplanetary Society, received the 1995 AIAA International Cooperation Award which is presented to recognise individuals who have made significant contributions to the initiation, organisation and/or management of programmes in the United States involving extensive international cooperative activities in space, aeronautics, or both. The award presented to Mr Harford carries the inscription: "For more than four decades of continuous contributions to and achievements in international cooperation in aeronautics and astronautics".

James Harford became the Executive Secretary for the American Rocket Society (ARS) in 1953 and spent 10 years dramatically increasing its membership. His accomplishments at ARS led to a merger with the Institute of Aeronautical Sciences forming the AIAA. He devoted the next 29 years (1963-92) to the success of every aspect of the Institute as Deputy Executive Director, Executive Director and Executive Director-Emeritus, respectively. In 1992, he became a Visiting Fellow at the National Air and Space Museum where he is currently writing a book focusing on the career of Sergei Korolev, the father of the Russian space programme.

Britain's Place In Space

On 23 March an invited audience at the Science Museum attended a forum on the subject of "Britain's Place In Space". The chairman, Dr. Peter Williams, set the theme by saying that the Forum would consider what Britain does rather than what it does not do.

The opening talk was by Mr Ian Taylor MP, the DTI minister with responsibility for space, who was appointed to that position on 20 July 1994. He emphasised the role of Science and Engineering Week particularly to inspire children to opt for science and technology subjects in their education. He pointed out that space plays a part in that. He argued that while the Government may not believe in spending money to put Britons into space it is highly active in areas such as space science and Earth observation. As a result the "country has an industry it can be proud of".

The Minister wanted more money to be leveraged in from the private sector and also wanted ESA to be more efficient at targeting its resources where they would achieve most benefit. By way of example he cited commercial navigation systems as an area where there was a need for greater European involvement.

He was followed by Dr David Leadbeater, Deputy Director of the British National Space Centre, who provided a more detailed account of UK activity and its organisation.

Sir John Houghton, Chairman of the Royal Commission on Environmental Pollution, spoke on Britain's leading contribution to Earth observation, Prof Ken Pounds, Chief Executive Officer of the Particle Physics and Astronomy Research Council, covered the UK science programme, and Mr Denis Cummings of Matra Marconi Space examined communications satellites. All three talks highlighted British success such as the fact that British scientists were getting more time on the Hubble Space Telescope than those from any other European nation based solely on the merit of their proposals. However the speakers also touched upon the recent funding problems due to currency changes and the increasing cost of the mandatory ESA programmes.

Mr David Cummings Head of Strategic Affairs at Matra Marconi Space suggested that Britain now formally joins the Ariane-5 programme. He pointed out that British companies proved to be the only possible European suppliers for some components and as a result the British Government has actually ended up contributing more to the development of Ariane-5 than some nations who are officially in the project. It seemed to him somewhat perverse that the UK taxpayer is making a contribution on the scale of other nations without the same formal representation in the programme.

The final speaker was Tim Radford,



Mr Ian Taylor, MP Parliamentary Under-Secretary of State for Trade and Technology.

science editor of *The Guardian*, who reviewed the public perception of space. He pointed out that despite the successes of the UK space programme the public remained apathetic to UK space while still being enthused by the more spectacular space events such as the recent flight by British born Michael Foale. There followed discussion from the floor which centred more on the areas not covered by the speakers and where UK involvement is very low - problems which are primarily caused by the very low UK civil space budget. It was pointed out that the British record in launchers in the 1960's was one of unequalled excellence and that this had been allowed to degenerate to virtually nothing, as had many other areas of the prime space engineering industry.

The evening finished with a reception in the Space Gallery where the guests could examine many examples of past British space engineering excellence at first hand. MARK HEMPSELL

ESA Space Science and UK's Declining Role

In December 1994, the Parliamentary Space Committee, under the chairmanship of Sir Michael Marshall MP, received an insider's view of ESA space science policy when Prof David Southwood, Chairman of the ESA Science Programme committee and Head of Physics at London's Imperial College, described ESA's successful science programme and drew attention to the worrying potential decline in UK participation.

According to Prof Southwood, the stability of ESA's science programme (through Horizon 2000 and, later, Horizon 2000+) is 'the envy of our Ameri-



can colleagues'. Although the United States' budget is much bigger, he said, the 'faster, cheaper, better' philosophy has so far 'failed to get missions off the ground'.

Horizon 2000 has moved Europe from being 'an ad hoc to a leading player' in space science, he said; so much so that Europe now leads in infrared astronomy, solar-terrestrial science, cometary science, astrometry and space-based fundamental physics, as well as having a strong position in X-ray astronomy.

Recent reports suggest, however, that Britain may be unable to participate significantly in ESA's future science programmes, particularly the Integral gamma-ray observatory (*Spaceflight*, August 1993, p.274) and Rosetta, its proposed comet-rendezvous mission. The problem, according to Prof Southwood, is that 'Britain's domestic spend has gone out of balance' on account of its mandatory subscription to the science programme (which is based on a country's GNP). This means that, once the subscription has been paid, insufficient funds will remain for British space scientists to develop instruments for the spacecraft, a role which they have played so successfully in previous missions.

The consequence of this, according to Prof Southwood, is that UK scientists will be 'locked out' of the Integral mission, the like of which will probably not recur in their professional lifetime.

Prof Ken Pounds, an X-ray astronomer at Leicester University and Chairman of PPARC (the Particle Physics and Astronomy Research Council) confirmed that although 'UK space science is world class' the country 'could probably not afford Integral'. Access to space, via ESA, he warned, 'is increasingly at a price we cannot afford', a fact that caused him to worry about the future of UK space science. ESA's policy of just retour, whereby member nations receive contracts in proportion to their financial contributions, was one of the 'restrictive practices within ESA that make it too expensive', he added.

Prof Southwood was optimistic about the future of space science, but said that it would be a pity if Britain was forced to relinquish its important role in ESA's space science programme.

EuroMir-95 Mission

Following their recent press conference at the European Astronauts Centre (*Spaceflight*, May 1995, p.175), the crew for the EuroMir-95 mission again met the press on 25 April at Star City outside Moscow where American astronauts also train for their visits to the Mir orbital complex.

The European Space Agency Representative for the mission, flying as a flight engineer, is the German Thomas Reiter. He will be the fourth German to go into space with the Soviet/Russians following Sigmund Jaehn (1978), Klaus-Dietrich Flade (1992) and Ulf Merbold (1994). Five Germans, including Merbold, have flown the shuttle. Sweden's Christer Fuglesang is the reserve ESA man.

The main event of the 135-day mission for Reiter will be an EVA outside the complex placing experiments on the exterior of the Spektr module. He will be the second European to make an EVA from Mir following Jean-Loup Cretien of France in 1988. (Briton Micheal Foale became the second European to make an EVA on STS-63 as he holds dual British and US nationality.)

The three-man EuroMir-95 mission will launch from Baikonur on 22 August 1995 as currently scheduled and will become the 20th main crew for the Mir complex being still aboard when Atlantis docks during STS-74.

The Russian flight plan involves two EVAs for repairs and restoration of Mir, according to ITAR-TASS. Forty per cent of the working time of the expedition will be spent on maintaining the viability of the complex whilst Reiter performs his science programme. They should also see the arrival of the fourth and final Mir module, Priroda. Much, however, rests on the success of the Spektr module as Mir is short of power and the solar panels that the module carries are vital for the complex.

NEVILLE KIDGER

New Dual Launch System

A stretched version of the highly successful "Mini SPELDA" dual launch system used on the Ariane 4 launch vehicle is to be developed by Matra Marconi Space.

SPELDA has been in use since 1986 and is already available in a range of three sizes that enables the usable volume inside SPELDA, and the Ariane 4 performance, to be optimised for specific missions. SPELDA (Structure Porteuse Externe Lancement Double Ariane) is an integral part of the external structure of the Ariane launch vehicle which allows two large spacecraft to be launched on each Ariane 4 rocket.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-70	8 June	Discovery	8 Days	TDRS-G	28.5
STS-71	19 June	Atlantis	11 Days	Mir-01 Mission	51.6
STS-69	20 July	Endeavour	11 Days	WSF-2, Spartan 201-03	28.5
STS-73	21 September	Columbia	16 Days	USML-02	28.5
STS-74	26 October	Atlantis	6 Days	Second Mir docking	51.6
STS-72	30 November	Endeavour	9 Days	Retrieval of SFU (Japan launch), Spartan/OAST free flyer	28.5

Atlas Programme - Beyond Year 2000

The commercial Atlas programme has grown in scale having a current commitment to produce 62 vehicles consisting of four launch vehicle configurations - the Atlas I, II, IIA, and IIAS. To date, Commercial Launch Services has contracts for 45 launches and launch options.

Beginning with the first commercial launch in 1990, AC-69, twenty Atlas/Centaurs have been launched from Cape Canaveral and the current manifest takes Atlas beyond year 2000. With two pads fully operational from the Cape, the launch flow is designed to allow 10 launches per year using both pads, with surge capability when necessary.

An additional Atlas/Centaur launch capability will soon be on-line with the completion of SLC-3E, located at Vandenberg Air Force Base in California. Currently scheduled to be completed and operational by the end of 1996, the West Coast launch facility will allow an increase in overall launch operations from both the East and West Coasts of the United States to accommodate a wider range of payload needs.

Atlas Launch Manifest.

Pad	AC No.	Payload	Atlas
1995			
A	112	UHF F/O No. 4	II
	114	MSAT	IIA
	116	UHF F/O No. 5	II
	118	DSCS No. 5	IIA
	119	Galaxy IIIR	IIA
	120	UHF F/O No.6	II
B	113	INTELSAT 704	IIAS
	115	INTELSAT 705	IIAS
	77	GOES J	I
	117	JSAT	IIAS
	121	SOHO	IIAS
1996			
		GE-I	IIA
		HOTBIRD II	IIA
		INMARSAT 3 No. 1	IIA
		INMARSAT 3 No. 2	IIA
		Loral DBS	IIA
		MLV No. 7	II
		SAX	I
		Telstar 4	IIAS
		UHF F/O No. 7	II
1997			
		DSCS No. 6	II
		2 Hughes Missions	IIAS
		UHF F/O No. 8	IIAS
		UHF F/O No. 9	II
		UHF F/O No. 10	II
1998-2000+			
		2 DSCS	II
		GOES K	I



Lift off at 1:18 am ET on 3 March 1995 from Pad 36B at the Cape Canaveral Air Station, Florida of the new Lockheed Martin's first Atlas, AC-115, carrying the 28th satellite for Intelsat. The rocket vehicle is the Atlas IIA which is the highest performing variant of the Atlas family. It uses two pairs of Thiokol Castor IVA solid rocket motors, one pair of which is lit at liftoff and the second pair when in flight.

Intelsat 705's 7,000 to 8,000 pound weight class spurred the development of the Atlas IIA and this launch was the third VII series to be launched by Atlas. Intelsat 705 was built by Loral Corporation which is half-owned in equal parts by four European Companies: Aerospatiale France, Alcatel Espaces of France, Alenia (Italy) and Daimler-Benz Aerospace of Germany. The satellite spent 18 months being fitted for spacecraft electronics at Aerospatiale in Cannes.

PETER GUALTIERI, WEST KENTUCKY NEWS

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The British Interplanetary Society

SPACELINE

Ariane Launches ERS-2

British Instruments In Orbit on Twin Spacecraft

During the night of 20-21 April, an Ariane 40 launch vehicle carried ESA's remote sensing satellite ERS-2 into orbit to join its twin ERS-1 which was launched in 1991.

Commenting on the launch, Britain's Minister for Space, Ian Taylor, said, "British Technology is once again helping Europe see straight to the heart of the matter. Climate change is something we must understand. The information which these instruments provide will be absolutely vital to that understanding".

ERS-2 will provide valuable information about the Earth's environment. It will monitor the oceans, land, ice and atmosphere, reporting back on a range of sensitive subjects from deforestation to pollution and helping us to live with our planet. It carries six instruments, two of which are British. The first of these instruments, ATSR-2 (Along Track Scanning Radiometer) will monitor sea surface temperatures globally to within 0.2 °C and carries additional channels for monitoring vegetation. It has been designed and built by a consortium led by the Rutherford Appleton Laboratory (RAL) who will continue to monitor and analyse data and imagery received throughout the instrument's lifetime.

The second instrument, AMI (Active Microwave Instrument) was built by a consortium headed by Matra Marconi Space (MMS). It operates in two ways:

1. As an SAR (Synthetic Aperture Radar) it uses microwave energy to scan and map the Earth's surface in any weather and at any time of night or day;
2. As a scatterometer it measures surface wind speed and direction over the oceans for use by meteorological services.

The stream of data received from ERS-2 will provide unique environmental information, just as its forerunner ERS-1. The two satellites will orbit in tandem for nine months, sending back the first ever twin sets of data for analysis. Britain has contributed around 14% of the total £420 million cost of the programme.

Joint Operation of ERS-1 and ERS-2

When it became clear towards the end of 1993 that ERS-1 would remain technically operational well beyond its 30-month design life, a great many users approached ESA with proposals for the combined operation of ERS-1 and ERS-2

for a period of six to nine months.

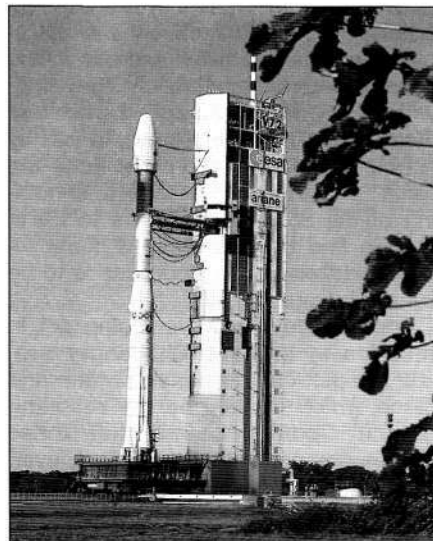
One of the three main areas to gain from an ERS-1/ERS-2 tandem mission is SAR interferometry. This is a technique for extracting highly precise information about the topography of the Earth's surface from the phase information provided by two or more SAR images acquired in the course of successive passes on the same orbit.

The most impressive results have been the production of "digital elevation models" - high-value cartographic products accurate to a few metres - and the measurement of shifts in the Earth's crust to within a few centimetres, for example following earthquakes, prior to volcanic eruptions or as a result of glacier flows.

The quality of the products does however depend greatly on the time interval between passes - from 3 to 35 days - and on the distance between satellite trajectories from one pass to another, a typical distance being several hundred metres. These two parameters can be systematically optimised by using two satellites instead of just one. The other two main areas to gain from the use of two satellites are (a) agriculture and hydrology and (b) oceanography.

The Ariane 40 launch vehicle (without strap-on boosters) in preparation on its table before launch, Kourou, French Guiana, 20 April 1995.

ARIANESPACE



Obituary



Anthony Thomas Lawton

It is with great sadness that we report the death, at the age of 67, of 'Tony' Lawton a Fellow of the BIS since 1952. For many years he was a member of Council and served on many of its Committees. He was a member of the Daedalus team, to which he brought his expertise in communications, being a contributor to Project Daedalus, the Final Report on the BIS Starship Study. He served two terms as President (1983-1985 and 1992-1994), his last two Society engagements being to preside at the Society's Diamond Jubilee anniversary meeting, SPACE '93 at Hastings in October 1993 and at its one-day Space Education meeting and exhibition in London in March 1994.

Throughout his career, he was a prolific writer and produced numerous papers for the *Journal* and *Spaceflight*. He wrote *Window in the Sky* and co-authored three other books with Jack Stonely. He carried out original research in Long Delayed Echoes which proved that signals that were thought to be coming from extra-terrestrials were actually a natural phenomenon and very earthbound. For this he was honoured as an Academician by the IAF.

Tony Lawton started his working life as an apprentice at Vickers in Weybridge and pursued his academic training at what was Kingston Polytechnic. His first notable task was as a member of the Barnes Wallis team, working under the guidance of the late Sir Leonard Cheshire on the SWALLOW research project that became the forerunner of the present-day swing wing aircraft. He worked on many projects in the field of avionics until his early retirement in 1987 due to ill health.

Although his long and illustrious career was mainly in the field of electronics and electronic systems engineering, his interests and knowledge ranged far and wide. His interest in astronomy was reinforced at the time he was in Australia and together with allied subjects remained his main hobby until his death. He was a well-known lecturer in the South of England where he talked to the BIS and numerous other interested groups. His retirement did not stop these activities and he also started broadcasting for Radio Sussex and Radio Solent on astronomical subjects.

P.P. WRIGHT

ERS-1 multi-temporal image of Rome and surroundings. ESA



Man and Astroman

Britain's National Theatre stages New Play about the Experience of Space

What is it really like to travel in space? This essentially unanswerable question - which remains a staple favourite of inquisitive members of the public - is explored in a new play, *The Blue Ball*, which opened at London's Royal National Theatre at the end of March. The title refers to the Earth as seen from space and the play itself is billed as an 'imaginative investigation into the experience of Space'.

A Long And Eventful Journey

The Blue Ball is the creation of young West Country playwright Paul Godfrey. The son of an aircraft engineer, Godfrey was born in 1960 and was thus an unwitting child of the "space age". However, he admits that unfolding events held no great significance in his life and that he was never able to make the intuitive connection between the TV images and the Moon and the stars visible in the night sky.

It was around the time that his play *Once in a While the Odd Thing Happens* completed its initial run at the National in 1990 that he received an unsolicited invitation to apply for a grant to travel to the States. Initially he was unable to think of a reason why he would want to cross the Atlantic and so threw the letter away. Then he awoke in the middle of the night with the idea of 'going to America to talk to the people who had walked on the Moon', and the application form was summarily exhumed from the rubbish bin. Even Godfrey knows not why he settled on the theme of space. All he knows is that he wanted to write about a subject which would be completely outside the realm of his own personal experience.

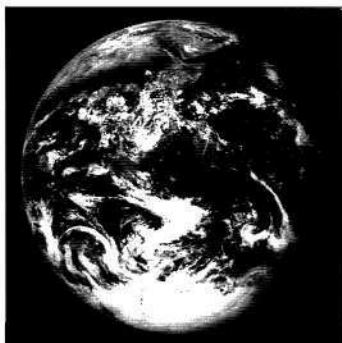
His first port of call was the Johnson Space Center. A further grant enabled him to spend a month at the Kennedy Space Center, during which he was able to witness the launch of STS-37 in April 1991. In search of the common bonds which exist between both astronauts and cosmonauts, Godfrey then raised the funds to make a trip to Star City near Moscow. He arrived in December 1991, just as the Soviet Union was falling apart at the seams.

On the last day of his trip he was given the opportunity to speak briefly with the resident crew of Mir, at which point he remembers 'I no longer doubted the reality of it and I recognised the full impact of the wonder of the experience, as much as I ever shall'. During the course of his 18 months of research he spoke to something like 25 astronauts and cosmo-

nauts. The process of digesting this research and actually writing the play took a further 18 months.

Engendering Disbelief

The play which resulted from these labours actually comprises of two distinct, but interrelated strands which continually co-orbit around each other much like a pair of binary stars. On the one hand we are given an account of the early pioneers of human spaceflight, who are tendentiously presented as figures of mythology, bereft of any nationality.



THE BLUE BALL
a new play
by Paul Godfrey
An imaginative investigation
into the experience of Space

During these scenes the actors all speak in flat British tones, and the resulting effect is strangely evocative of the "kitchen sink" dramas so prevalent in British film and theatre in the late 50s and early 60s. Collectively the astronauts and their families express inhibitions to each other. Publicly, they brim with confidence. Though the first of them, Alex (Dexter Fletcher), is told by his mentor (Nigel Terry) that he is the "best" pilot, it turns out that he is nothing of the sort. Alex returns to Earth only to find that he faces a blank future and that his only purpose is to be 'what you are, for life'.

The parallel narrative, being set in America in the post-Challenger era, has a much clearer sense of time and place which meliorates the resulting drama. Godfrey claims that these scenes are not autobiographical, even though they feature a playwright named Paul (Peter Darling) who is trying to fathom out the emotions experienced by astronauts. As Paul goes about his research he comes into contact with a broad cross-section of the "NASA" fraternity: a female mission specialist (Annabelle Apsion), an off-beat astrophysicist and his wife (George Anton and Sonia Ritter), a Shuttle pilot and his dutiful wife (William Armstrong and Gabrielle Lloyd), and finally a homely ex-Moonwalker and his gushing wife (Trevor Peacock and Annabelle Apsion again).

Few of the contradictions founded in the early history of the programme

BY DARREN L. BURNHAM

Oxford, UK

seem to have been resolved in the intervening years (some of which are exploited by Godfrey to great comic effect). Fleshed-out by some solid performances from all concerned (some of the cast members even followed in Godfrey's footsteps by travelling to Houston), the playwright's gentle probing brings all manner of tension bubbling to the surface. These are most tellingly exposed when the Shuttle pilot begins to talk a little too loosely, graphically revealing the awful truth of the Challenger disaster to the consternation of his blinkered wife.

Immediate Reality?

The play remains obdurately Earth-bound in outlook, and takes place in Stewart Laing's sparsely decorated set, which is awash, in the main part, in pale blue light. The most elaborate set-piece is reserved for the climax. As 'the Universe comes into the theatre' (quite literally - right over the audiences heads!), the playwright ascends skywards, with the proclamation that space travel is 'a question mark, hanging in the air'.

Godfrey had obviously made an earnest effort to convey the emotions arising from the exploration of space in *The Blue Ball*, but has he been successful? In search of expert opinion I solicited the views of US astronaut Marsha Ivins, who earlier that evening had taken part in a "Platform" conversation session along with Paul Godfrey and Helen Sharman. Ivins responded by deftly turning the question back on me 'Well do you think he did that?'. Besides empathising briefly with Godfrey, my initial thought was to dismiss the question as irrelevant. I patiently had not been in space so how

The Blue Ball draws anecdotes from the history of both the American and Soviet space programmes to provide a series of mythical snapshots of the first men in space. Here Nigel Terry plays Stone, a Korolev-like king-maker behind the first astronauts.

PHOTO: MARK DOUET





'I fulfilled my aspiration in one shot'. Oliver (Trevor Peacock) ponders the meaning of life after moonwalking as his wife Gina (Annabelle Apsion) looks on in a scene from *The Blue Ball* at the National Theatre. PHOTO: MARK DOUET

could I possibly hope to know? However, it was only on later reflection that I began to see that maybe Ivins had a point. The experience of space travel is not a commodity which can be bottled and sold over the counter. Whether as an active participant, or as an interested on-looker (be it as playwright, writer, or whatever) the viewpoint will always be different, depending upon the subtle distinctions in the make-up and character of each individual. Even if we could all make that short journey to low-Earth orbit (no further than the distance between London and Manchester) no two people would ever experience precisely the same emotional responses. As the veteran Moonwalker puts it in the play 'isn't it the way we perceive things that makes them what they are?'.

The play lasts as long as it takes to complete an orbit of the Earth, which is quite appropriate, for, as the closing lines reveal, the play has indeed gone full circle.

So, what of the original question? On the evidence of this play at least, one can only think and wonder.

Reference

Paul Godfrey, "The Blue Ball", Methuen Drama, London, 1995.

Acknowledgements

Christopher Millard (Royal National Theatre), Rod Hall (A.P. Watt) and Marsha Ivins.

What the Critics Say

'Whether intentionally or inadvertently, Godfrey's production does have something truthful to say: in that it exposes the impotence of human imagination in the face of this subject.'

Irving Wardle
The Independent On Sunday

'...the best one can say of this curiously earthbound play about space exploration is that it goes some way towards explain-

ing why this vast subject has failed to ignite the artistic imagination.'

Michael Billington
The Guardian

'I suspect that fragments of the play will come back to haunt me in six months' time: possibly the denouncement, in which Paul rises from the stage and vanishes through a hole in the ceiling, while the planets of the solar system descend to hover over the audience. Even here, though, the slightly ponderous event itself doesn't match up to the awe-inspiring stage-direction in the script.'

Robert Hanks
The Independent

'The laboured point is that space research is riddled with shabby ethics: that the race to the moon has more to do with nuclear fire power than rocket technology, and that the people involved in it are almost surgically detached from their emotions and imaginations.'

James Christopher
Time Out

'Curiously, for all his research, Godfrey ends up with no theories, not much meat and a rather interesting, idiosyncratic and well-written play about why this should be so.'

Michael Coveney
The Observer

'Godfrey (who also directs) has written a muddled piece in which he himself appears as an exceedingly dim central character.'

John Gross
The Sunday Telegraph

'Important questions - what has the space programme achieved? is the huge expense justified? - are virtually ignored, but far more damagingly, the drama totally fails to capture the sheer excitement of man's arrival on the moon.'

Charles Spencer
The Daily Telegraph

Science on the Stage

Bridging The Great Divide

Give or take the odd exception to the rule, such as Tom Stoppard's 1972 play, *Jumpers* (which constructs a moral dilemma by having a British astronaut callously leaving his colleague on the surface of the Moon to die), astronautics has yet to enter the firmament of the dramatist to any noticeable extent.

The problem, it must be said, is not just confined to space travel alone. The days have long since passed when it was possible for Renaissance scholars like Leonardo da Vinci and Francis Bacon to achieve equal notoriety in the realms of the arts and the sciences. Though we claim to live in a more enlightened age, it is a curious fact that the Industrial Age has been characterised by a deep schism between science and the classical arts, which is demonstrated by the divergent paths travelled by the Earth centred universe of the playwright, and the Copernican universe of the scientist. Relatively few plays of the Cold War era focused on scientific issues, and those that did - such as Friedrich Dürrenmatt's *The Physicists* (1962) and Heiner Kipphardt's *In The Matter Of J. Robert Oppenheimer* (1964) - tended to take a moralistic stance, dwelling on the potentially destructive folly of modern science. Perhaps the most enduring such text was Bertolt Brecht's finely wrought *The Life of Galileo* (the original 1947 production of which starred Charles Laughton), in which the inconsistencies of the battle between progressive thinking and established dogma foreshadow the developments of the nuclear age.

The balance has been redressed to some extent in the past half-dozen or so years, and an increasing number of new plays have taken the opportunity to look again at science in a new light. More often than not a scientific setting has been used as the backdrop for the exploration of more earthly matters. Some notable examples include Kevin Hood's *The Astronomer's Garden* (a tale of Eighteenth Century professional and sexual rivalries within the community attached to the Greenwich Observatory) and Susan Yankowitz's *Night Sky* (1991 - a noted female astronomer is transformed into a Stephen Hawking type figure after being afflicted by aphasia). After a decade spent tackling issues such as human rights, Tom Stoppard also returned to more familiar territory in 1988 with *Hapgood*, in which the activities of spies and double-agents are juxtaposed on the world of nuclear physics.

Meanwhile, on the fringes, small companies such as the Molecule Theatre of Science even go so far as to use live theatre to teach children the basics of science.

Now added to this growing canon of theatre based in or around scientific achievement comes Paul Godfrey's exploration of the exploration of space.

The Blue Ball, of which Godfrey is both the writer and director, is his second play for the National Theatre. Like its predecessor, *Once in a While the Odd Thing Happens*, (a well received biographical study of Benjamin Britten and Peter Pears), *The Blue Ball* is performed in the Cottesloe, the National's small studio theatre which seats approximately 400. His other credits include *Inventing a New Colour* (Royal Court, 1988) and *A Bucket of Eels*, which will be staged as part of the programme of the BT National Connections later this year. D.L. BURNHAM



Caleb Rocket Launches

Sir, I enjoyed the report on the NOTSNIK launch vehicle very much [1] as it is one of the publicly most unknown launch vehicles. I am very interested in the history of the follow-on Caleb rocket, which was shown on picture #1. I have found only one reference to this vehicle [2], which reports two launches in 1962. One was an ill-fated orbital attempt on an unspecified date in March 1962. The other one was a Caleb with only two stages on a successful suborbital mission launched on 25 July 1962. I doubt that only two launches have been made. I would be very pleased if anyone could help me out with some information on further launches of the Caleb rocket.

GUNTER KREBS
Schmitt, Germany

References

1. Joel W. Powell, "NOTS Air-Launched Satellites", *Spaceflight*, November 1994, Vol. 36, No. 11, p.374-375.
2. K.W. Gatland, *Spacecraft and Boosters-2*, Iliffe Books, London, 1965.

The author, Joel W. Powell, writes: In the course of my interview with the pilot that launched the NOTSNIK satellite vehicles, I also learned the details of five test launches of the Caleb follow-on rockets that he performed. Commander Bill West air-dropped the first two Caleb test vehicles from the same Skyray launch aircraft used in the NOTSNIK attempts. The first test, on 28 July 1960, involved only a live first stage motor, whereas the second test on 24 October 1960 involved two live stages (although stage two failed to ignite). Testing resumed a year later of an upgraded Caleb design (shown in the diagram) that required a switch to the more powerful F-4H Phantom II naval fighter. Designated Project Hi-Hoe, the rockets were instrumented as sounding rockets and were intended as prototypes for a four-stage orbital version for quick-reaction reconnaissance satellites. The programme was cancelled before any orbital attempts could be made. The first and second Phantom-launched Calebs suffered upper stage motor malfunctions (on 5 October 1961 and 26 March 1962) but the third and final test on 26 July 1962 worked perfectly and reached an altitude of 1,168 km (marred only by the failure of the scientific

payload).

I would also like to comment that in the absence of more concrete proof than the statement in the *Los Angeles Times* newspaper that two NOTSNIK vehicles did achieve orbit in 1958 (*Spaceflight*, Correspondence, December 1994, p.427), I do not believe that the project did achieve orbit due to the lack of published corroborating evidence from the crude tracking systems that did exist at that time.

Reference

Keith J. Scala and J.W. Powell, "A History of Air-Launched Space Vehicles", *QUEST*, Vol. 3 (Spring 1994), pp.35-41.

K.W. Gatland writes: The Caleb program was highly classified and at the time only the barest information was issued. Objectives were thought to range from high-altitude nuclear test monitoring to reconnaissance duty. The launch of 26 March 1962 was originally reported in the USA as a failed orbital attempt. This must now be queried. The air-launch on 26 July was definitely non-orbital, with Caleb restricted to just two propulsive stages and being released from the Phantom in a toss-launching manoeuvre. The probe, which carried an ion mass spectrometer and telemetry transmitter, reached an altitude of 725.5 miles (1,167 km) but although more than 1,100 sec of data were telemetered to the ground station, an equipment fault prevented measurements from being recorded. Shortly afterwards the Caleb programme was terminated when interest within the US Department of Defense turned to the ground-launched rockets Blue Scout and Blue Scout, Jr, under US Air Force management.

Robots: Love or Loathe?

Sir, John Gosling writes (*Spaceflight*, February 1995, p.43):

"...the Japanese have us at an advantage, not having developed the innate fear and distrust of robots reflected in our films and literature. That in such stories we often turn our soulless machine creations upon us to destructive ends is what might be termed a Frankenstein phobia, born of a Christian society that teaches us that God alone has the authority to create life."

On p.47 of the same issue, Darren Burnham writes:

"...a venerable Hollywood favourite - the cute lovable robot..."

Perhaps John Gosling should read Darren Burnham?

KEITH GOTTSCHALK
Cape Town, South Africa

John Gosling replies: Hollywood does indeed boast its share of cute robots, but I think the key word to remember is "cute". They are either stupid or funny or both, but seldom are they portrayed as equals with their human masters. When an adult movie is made about robots, it is more likely to be in the violent style of *The Terminator*. Even when a robot is made equal, the temptation to have it malfunction is almost irresistible. For instance, the android called Data in *Star Trek The Next Generation* has on several occasions run amuck.

The overwhelming message in western films and television is that robots cannot be trusted.

Space Log Dilemma - 1

Sir, I refer to the letter from Marcia Smith and Geoffrey Perry of The Kettering Group (*Spaceflight*, April 1995, p.140) inviting readers' comments on the manner in which manned space flight durations should be presented, especially in the light of the recent launch of an American citizen by a Russian rocket and then returning in the Space Shuttle.

The problem of astronauts/cosmonauts being launched in one spacecraft and landing in another is not new. But until now it has only occurred within the Russian space programme.

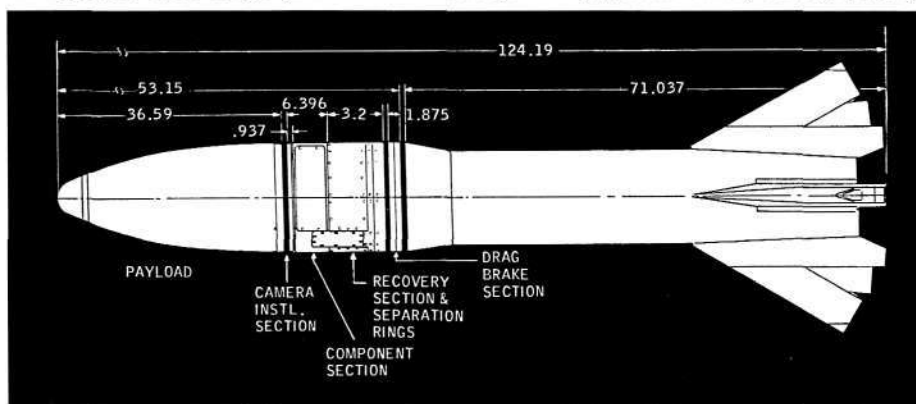
My solution has been to list durations by individual (as suggested) but then to list those individuals by nationality. This approach is not perfect, but with the aid of footnotes, I have made it work. The biggest obstacle has been the political changes in the former Soviet Union. Rather than regard the former Soviet Union and the Russian Federation as different nations, I have treated them as one and the same and have thus avoided the situation of having eight cosmonauts listed under two nations. At the last count, I consider that no fewer than 26 nations have had one or more citizens in space.

I am prepared to make my listing available to demonstrate how my method works if requested. My list is also in desperate need of correction as many of my mission durations have been calculated from mission reports etc, and may be in error. Is there anything that the Society can do to help me get my list verified?

A.P. TYZZER, FBIS
Worcs, UK

An upgraded Caleb design (dimensions in inches).

(Reproduced courtesy JOEL W. POWELL)



Ed: Anyone who feels they could help Mr Tyzzler may write to him, c/o the *Spaceflight* Office.

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Michael Foale at IMAX

NASA Astronaut on Visit to Home Country

Sir, On 27 March I was delighted to attend a presentation by NASA astronaut Michael Foale who flew on the STS-63 mission. During the lecture Britain's second space traveller presented footage of the fly-by of the Mir complex by the American shuttle at Britain's only IMAX theatre at the National Museum of Photography, Film and Television, in Bradford, West Yorkshire. Suffice to say that the IMAX footage was absolutely stunning.

Of equal interest was the 16mm footage of the mission during which Foale said that the hand-held laser ranging device he used did not work very well - only on things like windows - and the payload bay laser "melted" after the close approach. He said that Mir was so big that the devices ("toys") are probably not needed for the STS-71 docking.

Also, he said that during the rendezvous the cosmonauts were saying that the shuttle crew should come aboard and that "there's everything you want in here", meaning chocolates, caviar and - cigarettes!

Michael Foale related that during an earlier mission the Afghan cosmonaut Mohmand had been gasping for a smoke - and was allowed one. During a recent documentary programme shown on British TV a lighted match was shown floating around in the Mir Base Block.

NEVILLE KIDGER
Leeds, UK

Marsha Ivins Interview

Sir, Recently I had the opportunity to meet astronaut Marsha Ivins in London on a lecture tour. A veteran of three Shuttle flights (STS-32, STS-46 and STS-62) she currently leads the Astronaut Support Personnel Team at the Kennedy Space Center supporting Space Shuttle launches and landings while awaiting reassignment for a fourth mission.

I asked her about the forthcoming return aboard STS-71 of Dezhurov, Strekalov and Thagard after three months in space and any difficulties they might experience on landing. She told me that they will land in special seats, on their backs with their feet up, to prevent blacking out. The extra room for this will come from shuffling around some of the lockers in the cabin. After landing, if the cosmonauts are able to stand, they may be assisted from the Shuttle, down the steps. However if there are problems, a mobile white room can be brought up to the Shuttle and the cosmonauts removed in couches much like the Russian recovery teams use.

Asked about her own future plans, she replied that she was hoping for a Shuttle mission to dock with Mir in 1997; possibly the fifth mission of its kind. She was not to be included on STS-75, she said, as others had greater reason and priority than herself to refly the tethered satellite mission.

N.C. DaCOSTA
London SE12

Sir, Recently I was lucky enough to enjoy a fascinating IMAX presentation and talk by Dr Michael Foale, just returned from rendezvousing with the Mir space station and performing the first British space walk. Dr Foale gave a fascinating introduction to the IMAX film "Destiny In Space"; and showed us some enthralling uncut 16mm and IMAX footage of his latest mission, including spectacular close-ups of Mir. He went on to answer the audience's questions, and proved throughout to be extremely friendly, open and approachable.

FRANCIS FRENCH
Education Department
Museum of Science and Industry
Manchester, UK



Michael Foale silhouetted against film of the Earth from space while showing uncut IMAX footage of his spacewalk.

FRANCIS FRENCH



Francis French (left), who is an astronaut/cosmonaut autograph collector and archivist, is greeted by Michael Foale at the IMAX Theatre, Bradford.

FRANCIS FRENCH

Austrian Space Medicine

Sir, From 6 to 16 March 1995, cosmonauts Viktor Afanasyev, Jurij Usachev (both Soyuz TM-18 crew members), Yuri Malenchenko and Taldat Musabayev (both Soyuz TM-19 crew members) visited Austria. The cosmonauts were invited by the Austrian Society for Aerospace Medicine (ASM). During a visit to ASM I had the opportunity to talk with the Soyuz TM-19 cosmonauts and they told me about their life on board Mir. During their two-week visit to Austria the cosmonauts explained the work which had been conducted with the Austrian medical experiments on board the space station since the AustroMir 91 mission (2-10 October 1991).

The purpose of the experiments had been to collect data about the human body during long-duration flights.

Dr Valeri Polyakov who landed on 22 March 1995 also worked with these experiments during his 438-day stay aboard Mir. After landing Dr Polyakov and his colleagues Alexandr Viktorenko and Yelena Kondakova were examined by researchers from ASM and IMBP (Institute of Biomedical Research, Moscow).

As a result of the cooperation between Russian and Austrian researchers, Austria is number two in the field of aerospace medicine.

MARIUS WERNER
Vienna, Austria



Left to right: cosmonaut Yuri Malenchenko, Marius Werner (the writer of this letter) and cosmonaut Taldat Musabayev.

Space Log Dilemma - 2

Sir, Marcia Smith and Geoff Perry in the April 1995 issue of *Spaceflight* address a problem that is not of this time per se. When, about fifteen years ago, we started to build an automated database (at *ribs Space Consultancy & Insurance Databases*) on space related launches and launch attempts, we ran into a number of difficulties. In officially published databases at that time (TRW, RAE etc), weights were partly quoted in pounds and from 1957-1962 the Greek alphabet was used in the international designation (WWA/COSPAR). We converted pounds into kilos and renumbered the launches in the way used since 1963.

There are more problems than those of a statistical nature only, apart from the problem that was raised by Marcia Smith and Geoff Perry. We have always found the 'records of human space flight' to be a bit artificial and nationalistic. It is fine with us that Valery Polyakov has the record of the human being who has been longest in space and that Russia has the longest duration of space station(s) in orbit, or that the Americans were the first and only people on the Moon (by the way, was there ever an [American] Indian on the Moon?), but we do not approve of the nationalistic tinge that is often given when records like that are compared. What about the Japanese journalist Toyohiro Akiyama who spent some time on the Mir Space Station as a non-contributing passenger compared to Japanese astronauts who fly as mission payload specialists on the US Space Shuttle. Should there be, in the future, a distinction between passengers and crew?

Other Space Log Dilemmas are the numbering/naming of payloads, e.g. the Foton series of Russian spacecraft, US launches that are not even named and only reluctantly admitted months after launch, without orbital parameters. The US is, in some respects, more secretive than the former Soviet Union.

In time to come we will learn more and more about Russian space launches, both actual and past. Most of the changes will be in 'missions' attributed to satellites, especially those launched in the Kosmos series. It is not uncommon any more for Russian press releases to state that a launch was of a military nature. Maybe the US should follow this example.

Before this decade is over we will have adapted our databases several times. What if USSPACECOM decides that the Japanese M-3S-II launch with the EXPRESS payload on 15 January 1995 did take a payload into orbit. We hope that if they do, they will do it quick as the less changes we have to make to our databases the better.

To overcome some of the problems described here, we at *ribs Space Consultancy & Insurance* attribute a special code to each payload that has been launched into space, whether it reached orbit or not (or even left the launch pad). This code represents the mission of the specific payload and can be extended to fit more qualifiers if need be. In the case of Foton missions the code could be $\alpha 1234567$, in which α would stand for a letter representing microgravity materials

production; 1234 would relate to specific payloads being launched with a specific launch vehicle from a specific launch site; 5 would classify the payload as military, civilian or both; 6 would indicate whether it is experimental or operational; 7 would say whether the launch was unsuccessful or (partly) successful, and so on.

By hyperlinking inputs to comments we are always able to classify and qualify any payload. It pays off in research. If I would like to have a readout of all Foton related launches (irrespective of given names) I simply ask for $\alpha 1234$ and that is it. Consequently, asking for α would give me all microgravity materials production related launches and payloads, including Mir experiments and Foton follow-ons. Likewise astronauts, cosmonauts, spationauts or whatever nauts can be coded. In so coding all launches and launch attempts and with the use of computers, we circumvent the problems described.

HENK H.F. SMID
Member BIS
The Netherlands

Soviet Spacesuits

Sir, In the Correspondence section of the January 1995 issue, J.K. Andersen notes the similarity between the pressure suits worn by the Voskhod 2 crew in a pre-launch photograph and by Vladimir Komarov in a Soyuz 1 photograph.

Both garments pictured are the "Yastreb"-type extravehicular pressure suit, used by Alexei Leonov on Voskhod 2 (1965) and by Yevgheny Khrunov and Alexei Yeliseyev during their extravehicular activity (EVA) transfer from Soyuz 5 to Soyuz 4 (1969).

The Voskhod 2 crew, Leonov and his commander, Pavel Belyayev, both wore this type of suit throughout their flight, probably because the Voskhod cabin was too small to allow them to don and doff the suits in flight. Belyayev remained in the cabin during Leonov's historic spacewalk, but wore the suit in case he had to exit the craft to come to Leonov's aid. Khrunov and Yeliseyev donned their suits in orbit, in preparation for their EVA.

An interesting question is *why* Komarov was photographed wearing an EVA suit. Komarov was the solo pilot of Soyuz 1 (1967) and would have welcomed Khrunov and Yeliseyev into his craft after their EVA transfer from Soyuz 2, piloted by Boris Volynov, had the Soyuz 1/Soyuz 2 missions gone as planned. This is strongly supported by a published group photograph of Yuri Gagarin, Komarov, Valery Bykovsky and - wearing Yastreb suits - Khrunov and Yeliseyev. The transfer was finally accomplished in January 1969, when Khrunov and Yeliseyev left Soyuz 5, commanded by Volynov and joined Vladimir Shatalov, the solo pilot of Soyuz 4.

In April 1994, I saw and photographed an exhibit on the Soyuz 4 and 5 flights in the cosmonauts' museum at Star City, Russia, in which individual portraits show Khrunov, Yeliseyev and Volynov - but not Shatalov - wearing the Yastreb EVA suit. But, neither Komarov, Shatalov nor Volynov wore this or any other pressure



Why was Komarov photographed wearing an EVA suit?

suit during these Soyuz missions, using instead lightweight "track suits", as worn by the Voskhod 1 crew (1964) and all Soyuz crews until Soyuz 12 (1973).

I suggest that the well-known Komarov photograph and the less-known Volynov photograph were just publicity shots, perhaps taken during suit familiarisation sessions involving the EVA crew members, and not, as Andersen suggests of Komarov, a few hours before the launch of Soyuz 1. Shatalov (Komarov's replacement) is *not* shown in a Yastreb in his portrait in the Star City exhibit, unlike Volynov (Bykovsky's replacement).

The practice of photographing astronauts in pressure suits they were never likely to fly in is not unknown in the United States' space programme. Consider the photographs of astronauts Joe Allen and Story Musgrave wearing the high-altitude ejection suits used only during the Space Shuttle Orbital Flight Test (OFT) missions, STS-1 through 4. (Those photographs are ironic because the expansion of shuttle crews from only two pilots to 4-8 crew members including mission and payload specialists on STS-5 and subsequent flights required NASA to forego the use of ejection seats and the associated pressure suits.) When I asked Musgrave about these photographs several years ago, his answer was that during Skylab, all the astronauts were photographed in Skylab suits (I have one of astronaut Karl Henize, who was never on a Skylab prime or backup crew) and later, during OFT, they were all photographed in OFT suits. Musgrave's portrait in the OFT suit even appears in a recent NASA poster of active astronauts, over a dozen years after it was made.

Interestingly, the practice of portraying space travellers in pressure suits they never wore in flight reached an unusual extreme in a series of cosmonaut portraits issued in the Soviet Union and recently offered for auction in the United States. Several early cosmonauts are portrayed in what is obviously the same photograph of a 1973-version of the "Sokol" launch and entry suit pressure suit, against the same starry background - including Valentina Tereshkova, who flew only once, at least 10 years earlier, in Vostok 6!

JOHN B. CHARLES
Houston, Texas

Visit to Japan

Sir, Regarding my two-month stay in Japan last summer my travels took me from Tokyo to Kitakyushu and the excellent 'Space World' Theme Park complete with Space Museum, Space Camp and a full size replica of a space shuttle. (*Spaceflight*, March 1995, p.95). From there I went on to Nagasaki, then south to Kagoshima and the active volcano Sakurajima. A ferry took me across the water to Tanegashima Island where I visited the NASDA test and launch facilities. I hope that the enclosed photographs will be of interest to *Spaceflight* readers.

Taken on 15 September 1994 they show the H-I launch complex at the time undergoing modifications to accommodate the new J-I launch vehicle and the interior of the original launch control room which has been converted to allow visitors the chance of launching an H-II rocket, courtesy of some excellent computer graphics. Assuming that you can read the Japanese display board and touch the sensitive LCD keypad (which, incidentally, I could not) your 'launch' should be a complete success!

GARY SIMMONS
London E18



Above: The visitors' 'launch' control room at the NASDA Space Centre.

Right: NASDA's H-I launch complex (Osaki Range). The service structure of the H-II launch pad (Yoshinobu Range) can be seen in the distance on the right.



"Sonny Carter"

Sir, I enclose a photo which readers of *Spaceflight* may find of interest. It was taken at Robins Air Force Base Museum, Georgia, USA and shows a wall to the memory of astronaut M.L. "Sonny Carter" who died in a passenger aircraft crash at Brunswick, Georgia on 5 April 1991. He was in training for Mission STS-42 at the time of the accident.

HOWARD M. MASON
Cheshire, UK



1995 Astronaut Candidates

Sir, Further to the article in *Spaceflight*, March 1995, p.107 with regard to the new astronaut intake at NASA, in which the 19 candidates, ten pilots and nine mission specialists were joined by two international mission specialists, the astronaut class of 1995 is as follows:

Pilots

Scott D. Altman, Lt Cdr, USN, 35.
Jeffrey S. Ashby, Commander, USN, 40.
Michael J. Bloomfield, Major, USAF, 35.
Joe F. Edwards, Lt Cdr, USN, 37.
Dominic L. Gorie, Commander, USN, 37.
Rick D. Husband, Major, USAF, 34.
Steven W. Lindsey, Major, USAF, 34.
Pamela A. Melroy, Major, USAF, 33.
Susan L. Still, Lieutenant, USN, 33.
Frederick W. Sturckow, Capt, USMC, 33.

Mission Specialists

Michael P. Anderson, Major, USAF, 35.
Kalpana Chawla, PhD, 33.
Robert L. Curbeam, Jr, Lt Cdr, USN, 33.
Kathryn P. Hire, 35.
Janet L. Kavandi, PhD, 35.
Edward T. Lu, PhD, 31.
Carlos I. Noriega, Major, USMC, 35.
James F. Reilly, 40.

Stephen K. Robinson, PhD, 39.

Canadian Space Agency (CSA)
David R. Williams, MD, 40.

National Space Development Agency of Japan (NASDA)
Takao Doi, PhD, 40.

NICK DEAKIN
Walsall, West Midlands

Buran

Sir, A "Buran exhibition complex" is scheduled to be opened later this year in Moscow's Gorky Park on the banks of the Moskva river. By then, the original interior of Gorky Park's Buran orbiter (see *Spaceflight*, Vol. 36, p.249) will have been replaced by a theatre. Outfitted with chairs that can swivel around two axes, one hopes to offer visitors a space flight-like experience on the ground. Next to the Buran, three dome-shaped exposition halls are currently under construction. The work is being carried out by a Moscow company named Cosmos-Zemlya which also produces space food for the crew on Mir.

According to a Cosmos-Zemlya

spokesman, the exhibited Buran is a former non-flying static testbed which was moved on a floating platform propelled by three tugboats from Tushino to Gorky Park in the night of 21-22 October 1993. It is one of the three Buran orbiters completed (originally, a fleet of 15 was foreseen). The two other Burans made a similar trip on the Moskva river at the start of their career when they were shipped from Tushino (NW of Moscow) to the Zhukovsky test flight centre (SE of Moscow). One was a non-orbital prototype which, equipped with turbojets, was used to study low-speed aerodynamics. It could take-off and land under its own power. The other was the real orbiter which was subsequently transported from Zhukovsky to Baikonur on the back of an Antonov An-225 Mriya.

RENE DEMETS
The Netherlands

The interior of the Buran in Gorky Park on 5 February 1995.



Lunar SETI

Sir, The Search for Alien Artefacts on the Moon (SAAM) [1] has aroused considerable interest [2] and current results of the programme may be of interest to *Spaceflight* readers.

1. Theoretically the Moon is able to attract and accumulate artefacts [3,4] and hence could be an indicator of alien presence in the Solar System or around nearby stars during the last 4×10^9 yr.
2. The following principles of lunar archaeology can now be formulated [4] as a consequence of recent theory [5]:
 - Only big ($> \sim 1$ m) ancient artefacts could be found on the lunar surface;
 - The discovery of small artefacts would most probably be in the regolith layers at depths less than about 10 m, especially in craters;
 - The original site of the artefact would usually be different from its discovery site;
 - The local archaeological search would need to be carried out within a radius of ~ 0.5 km (to cover the dispersal area of artefacts at least);
 - It is the smallest and most dense artefacts that would more accurately locate a site of ancient intelligence activity.
3. There are formations on the Moon which seem promising objects for SAAM (e.g. lava tubes, pit-like depressions less than 10^6 yr old, unusual domes of unknown origin and "lattice patterns" in the lunar relief) [4].
4. There are types of transient lunar phenomena (LTPs) which could be artificial. For example, star-like phenomena of 20-60 min duration [6] are usually interpreted as reflections of sunlight from a flat mirror surface [7]. But such exotic surfaces must be relatively new ($< 3 \times 10^5$ yr old) and would not be expected to be found in the very old craters where LTPs are observed [3,5]. Moreover, the long duration (15 min to 2 h) of some nocturnal points of light on the Moon, their brightness and their absence of visible variability do not tally with any traditional "natural" explanations (e.g. electrical discharges, luminescence of gas, meteor impacts).
5. The invasion of Earth vehicles in certain lunar regions gave rise to a statistically significant, real, temporary increase in the probability of LTPs there [4,8], but does not provide an adequate explanation of the effect as it was too selective observationally.
6. To summarise: it could be expected that alien artefacts, if they exist on the Moon, are concentrated in the region of the crater Aristarchus (where there are lava tubes, nocturnal points of light, possible mirrors, etc), on the peak of the southern wall of the crater Malapert (this being an optimal site for alien reconnaissance devices, because the Earth would always be seen there and the sunlight is accessible about 94% of the time), in the crater Herodotus (a possible mirror), in the

crater Gassendi (possible mirrors, invasion effect), in Mare Tranquillitatis (unusual depressions, lava tubes, invasion effects, etc [3,4]).

So lunar SETI seems promising and could moreover be a part of modern plans for the exploration and colonisation of the Moon.

ALEXEI V. ARKHIPOV
Institute of Radio Astronomy
Kharkov, Ukraine

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Counting Mir Cosmonauts

Sir, NASA still cannot seem to get its Russian space statistics straight, without tripping up somewhere. On the Soyuz TM-21 launch of the Mir-18 crew it was reported that the three new cosmonauts "became the 42nd, 43rd and 44th humans to have flown on Mir". As the following list shows, due to repeats, there had been 55 visits by 42 different humans before this launch. Since Strekalov had already been aboard Mir, he cannot count as a new Mir cosmonaut, so Thagard is the 43rd, not the 44th, to visit Mir.

Maybe this is obsessively picky, but if you are going to try to provide such precise enumerations, you ought to make adequate quality control efforts.

To err is human, and when it comes to counting, everybody has slipped up. I am sure I will make my share as I have in the past, and I will try to accept correction with as much grace and humility as I can, as long as such corrections are offered in constructive humour, as these are.

People aboard Mir

- 01 Kizim
- 02 Solovyov V
- 03 Romanenko
- 04 Laveykin
- 05 Viktorenko
- 06 Aleksandrov
- 07 Faris
- 08 Titov
- 09 Manarov
- 10 Levchenko
- 11 Solovyov A
- 12 Savinykh
- 13 Aleksandrov (BU)
- 14 Lyakhov
- 15 Polyakov
- 16 Ahad
- 17 Volkov

- 18 Krikalyov
- 19 Chretien
- Viktorenko again [visit 20]
- 20 Serebrov [21]
- Solovyov A again [22]
- 21 Balandin [24]
- 22 Manakov [25]
- 23 Strekalov [26]
- 24 Afanasyev [27]
- Manarov again [28]
- 25 Akiyama [29]
- 26 Artsebarskiy [30]
- Krikalyov again [31]
- 27 Sharman [32]
- Volkov again [33]
- 28 Aubakirov [34]
- 29 Viehbock [35]
- Viktorenko again (#3) [36]
- 30 Kaleri [37]
- 31 Flade [38]
- Solovyov A again (#3) [39]
- 32 Avdeyev [40]
- 33 Tognini [41]
- Manakov again [42]
- 34 Poleshchuk [43]
- 35 Tsibilyev [44]
- Serebrov again [45]
- 36 Haignere [46]
- Afanasyev again [47]
- 37 Usachyov [48]
- Polyakov again [49]
- 38 Malenchenko [50]
- 39 Musabayev [51]
- Viktorenko again (#4) [52]
- 40 Kondakova [53]
- 41 Merbold [visit 54]
- 42 Dezhurov [55]
- Strekalov again [56]
- 43 Thagard [57]

It all adds up!!

JAMES OBERG
Texas, USA

Commonwealth Space Agency

Sir, Would a Commonwealth Space Agency be such a fanciful idea. The Commonwealth has English as a common language, the language which is coincidentally the language of science and technology. *Spaceflight* has pointed out that the cost of constructing satellites is coming down to a point where medium ranking nations can build them and Commonwealth nations like India have even built launch vehicles. If individual nations can launch satellites, then surely the Commonwealth collectively could support a modest space programme.

A Commonwealth Space Agency should not attempt to rival the "supergiants" of America and Russia, or even Europe, but should choose projects tailored to a budget it could sustain. The size of contribution would vary commensurate with the size and wealth of the contributing nation or organisation. Larger industrial states would be expected to contribute more, while smaller nations, like Pacific island states, should feel that they have a stake in this endeavour and are not left out.

If the idea of a space agency is not possible, then at least, the countries of the Commonwealth should agree a common approach to space exploration.

DAVID PHILIP GRAY
Bucks, UK

'Objects on the Moon' Competition

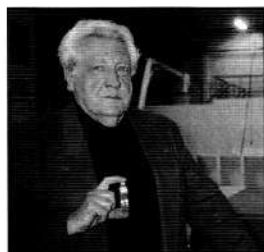
With the ending of the Apollo program, the Moon returned to being its undisturbed former self - but not quite, as many left-overs from the six Apollo landings remain as evidence of man's explorations. Amongst some of the most unusual man-made objects on the Moon are those that astronauts took with them as part of their small allowance of personal luggage. Our competition this month is about such objects and provides an opportunity for readers to win a prize from the collection of new BIS Space Shuttle videos*.

Prizes: The first three correct entries to be opened after the closing date of 6 July 1995 will receive a copy of:

STS-64: Mission Highlights

This video covers the flight of Discovery in September 1994 and shows the release and recovery of the SPARTAN satellite and extended EVA activities.

To Enter: Answer A, B or C to each of the following three questions, using each of these letters once:



Paul van Hoeydonck

1. The Belgian, Paul van Hoeydonck, is the only sculptor to have an item of his work on the surface of the Moon. It has been there since July 1971 when it was left by the Apollo 15 astronauts. A copy of the sculpture is permanently exhibited at the Euro Space Center in Belgium and is shown in the photo being held by Paul van Hoeydonck. The name of the sculpture is:

'The Astronaut'

where the missing word is:

- A. Lone B. Forgotten C. Fallen
2. Alan Shepard is probably best remembered as the first person to play golf on the Moon during an Apollo 14 EVA. The number of golf balls that Shepard had with him was:
- A. One B. Two C. Three
3. At the end of the Apollo 15 lunar surface mission, David Scott drove the Moon buggy to a small rise to the east of Falcon to enable the TV camera to be aimed back at the LM and record the liftoff. He then pulled out a small Bible and placed it on top of the buggy's control panel. The colour of the Bible was:
- A. Red B. White C. Blue

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 6 July 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

*Tapes are VHS PAL format only and are not compatible with the US NTSC system.

Title/Name

Address

Spaceflight Crossword

No. 22

ACROSS

1. Seen by weather satellite
4. Action list for a computer
8. Sounds brisk
9. Old-fashioned
10. Soft sweetmeat that distorts ?
11. Act a part
13. Comestibles
15. Deprive of cover
17. Constant state of equilibrium
20. Back part
22. Pulling vehicle
24. Spacious
26. Danger warning
27. Russian cavalryman
28. Makes safe
29. Topic set for discussion

DOWN

1. Apollo 1 fatality
2. Lubricated
3. Temperature units

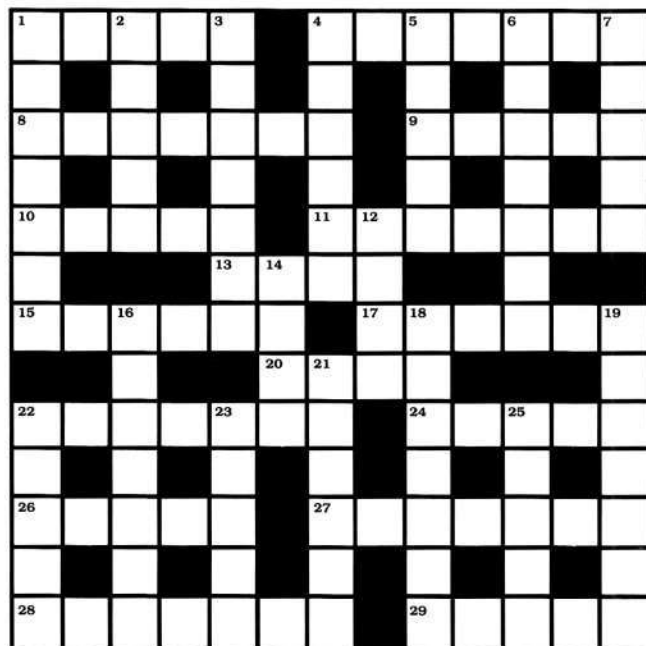
4. Punctual
5. Command
6. Equips industrial facility for manufacture of new products
7. Device for data transmission by a communications system
12. Acronymic name of weather satellite series launched in 1966 to 1969
- 14 and 25 DOWN Flying-machine (9)
16. They include the Earth
18. Passage of a star over the meridian
19. Grainy pattern of an astronomical photographic image
21. Sets launch vehicle upright on the launch pad
22. Line marked by a recording instrument
23. Coach
25. See 14. DOWN

Solution will appear in the July issue.

Solution to Crossword No.21.

ACROSS: 1. SPAS; 3. Memorial; 9. Outer; 10. Octagon; 11. Tow; 13. Woe; 14. Ounce; 15. Rotate; 17. Enlist; 19. Crest; 20. Tin; 22. Yon; 24. Cabinet; 25. Views; 27. Exercise; 28. Gaia.

DOWN: 1. Scout; 2. Apt; 4. Elope; 5. Outworn; 6. Ingenuity; 7. Longest; 8. Crew; 12. Wetherbee; 15. Recycle; 16. Titanic; 18. States; 21. Nova; 23. NASDA; 26. Eta.



SATELLITE DIGEST-277

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Design	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Endeavour	1995-007A	Mar 2.28	KSC	Shuttle	98,740	Mar 2.45	28.46	91.59	347	358	[1]
Cosmos 2306	1995-008A	Mar 2.54	Plesetsk	Cosmos	1,000	Mar 2.85	65.85	94.47	469	517	[2]
Cosmos 2307	1995-009A	Mar 7.39	Tyuratam	Proton-4	1,300 ?	Mar 25.35	64.80	675.77	19,113	19,149	[3]
Cosmos 2308	1995-009B				1,300 ?	Mar 21.90	64.79	675.74	19,101	19,159	
Cosmos 2309	1995-009C				1,300 ?	Mar 18.66	64.79	675.73	19,117	19,142	
Soyuz-TM 21	1995-010A	Mar 14.33	Tyuratam	Soyuz	7,150 ?	Mar 18.17	51.64	92.43	391	396	[4]
SFU	1995-011A	Mar 18.33	Tanegashima	H-2	4,000 ?	Mar 23.86	28.46	94.24	467	496	[5]
Himawari 5	1995-011B					Apr 1.21	1.06	1,434.74	35,731	35,789	[6]
Cosmos 2310	1995-012A	Mar 22.17	Plesetsk	Cosmos	825 ?	Mar 22.38	82.94	105.02	980	1,011	[7]
INTELSAT 705	1995-013A	Mar 22.26	ER	Atlas 2AS	3,660	Apr 1.03	0.08	1,439.84	35,614	36,106	[8]
Cosmos 2311	1995-014A	Mar 22.70	Plesetsk	Soyuz	6,500 ?	Mar 22.88	67.19	89.54	168	336	[9]
DMSP-2 8	1995-015A	Mar 24.59	WR	Atlas E	823	Mar 24.77	98.83	101.93	847	854	[10]
Gurwin 1		Mar 28.42	Plesetsk	Start	55						[11]
UNAMSAT 1					12						
EKA 2					200						
BRASILSAT B2	1995-016A	Mar 28.97	Kourou	Ariane 44LP	1,780	Mar 31.16	2.67	765.31	6,766	35,908	[12]
Hot Bird 1	1995-016B				1,800	Apr 1.05	0.36	1,330.30	31,490	35,890	[13]

NOTES

- STS-67 mission, carried seven astronauts: S.S. Oswald (commander), W.G. Gregory (pilot), J.M. Grunsfeld (mission specialist, MS-1), W.B. Lawrence (flight engineer, MS-2), T.E. Jernigan (payload commander, MS-3), S.T. Durrance (payload specialist, PS-1) and R. Parise (PS-2). Primary payload for the mission was ASTRO 2, carrying three instruments attached to a Spacelab Instrument Pointing System: assembly with a mass of 7,885 kg remains fixed to the shuttle's payload bay. ASTRO 2 was dedicated to ultra-violet astronomy. Landed Edwards Air Force Base Mar 18.91.
- Main satellite launched for calibration of land-based radars: four sub-satellites ejected (1995-008C-F) a few days after launch.
- Three "Uragan" navigation satellites launched into plane 3 of the GLONASS system.
- Piloted spacecraft, carrying V.N. Dezhurov (commander), G.M. Strekalov (flight engineer) and N.E. Thagard (first American to be launched using a Russian spacecraft). Docked with Mir Complex at the rear port on Kvant 1 Mar 16.31. Astronauts are to remain in orbit until US shuttle Atlantis (STS-71 mission) docks with Mir Complex in mid-1995, which will make Thagard's flight the longest by an American: spacecraft will return to Earth approximately September 1995 carrying two cosmonauts to be launched aboard the shuttle.
- Space Flyer Unit is a reusable platform, planned for recovery aboard the United States STS-72 mission in late 1995. Mass quoted above is at launch: that projected for the time of shuttle retrieval is 3,200 kg. Carries microgravity experiments.
- Himawari 5 (GMS 5, "Geostationary Meteorological Satellite" before launch) is a meteorological satellite, forming part of the Global Observing System for the World Weather Watch: mass quoted above is at launch, on station it is 345 kg. Satellite to be operated over 140 °E.
- Navigation satellite in the military "Parus" system, co-planar with Cosmos 2184.
- Communications satellite, built by Space Systems/Loral for INTELSAT. Mass of the satellite quoted above is at launch: the dry mass of the satellite is approximately 1,500 kg. To be operated over 310 °E.
- Fourth generation close-look photoreconnaissance satellite, expected to remain in orbit for about two months.
- Block 5D-2 "Defense Meteorological Satellite Program" payload.
- Maiden flight of Start launch vehicle failed to reach orbit. Gurwin 1 was a technology demonstrator, UNAMSAT 1 was an amateur radio satellite and EKA 2 was possibly a dummy satellite (reports about this differ).
- Brasilsat B2 is a telecommunications satellite (data and television transmissions, telephone and telex links) launched for Embratel in Rio de Janeiro, Brazil. The mass quoted above is that at launch: on station it is 1,052 kg and the dry mass is 856 kg. The satellite is to be operated over 295 °E.

- Hot Bird 1 is a television and radio broadcasting satellite, operated by Eutelsat (Paris). Mass quoted above is at launch: on station it is 1,050 kg and dry 840 kg. To be located over 13 °E.

ADDITIONS AND UPDATES

- 1983-094A RCA Satcom 2R was manoeuvred off-station over 287-288 °E approximately Mar 5-6.
- 1985-025A INTELSAT 510 was manoeuvred off-station over 65-66 °E approximately Mar 17.
- 1985-087A The period during which INTELSAT 512 was relocated was 1994 Sep 18-29, not Sep 18-18 as previously quoted in "Satellite Digest".
- 1989-062A TVSat 2 had its orbit restabilised over 359 °E approximately Mar 11.
- 1993-029A Cosmos 2244 decayed from orbit Mar 18.
- 1993-044A Cosmos 2258 was manoeuvred off-station during Mar 1-2 and has been retired: add the following orbital data (the first is the operational orbit): Mar 1.45, 65.03°, 92.78 minutes, 399 km, 422 km, 295° Mar 2.29, 65.03°, 91.43 minutes, 271 km, 418 km, 263° Mar 2.35, 65.03°, 90.99 minutes, 229 km, 418 km, 266°. The satellite is now decaying from orbit. This leaves Cosmos 2264 (1993-060A) and Cosmos 2293 (1994-072A) as the operating EORSAT constellation.
- 1994-006F ODERACS E decayed from orbit Mar 3.
- 1994-025A Cosmos 2280 was de-orbited Mar 10.
- 1994-063A Soyuz-TM 20 undocked from the Mir Complex Mar 20 and landed 55 km (some reports have said 36 km) north-east of Arkelyk Mar 22.17 with cosmonauts Viktorenko, Kondakova (both launched on Soyuz-TM 20) and Polyakov (launched on Soyuz-TM 18) on board. With this landing Polyakov has completed the longest space mission by a human being at 437d 17m 58m 16s and also holds the record for the total time in orbit. Similarly, Kondakova completed the longest flight by a woman, her flight time (and also that of Viktorenko on this flight) being 169d 5h 21m 20s.
- 1994-075A Progress-M 25 undocked from the Mir Complex Feb 16.55.
- 1995-003A UFO 4 was relocated from 189 °E to 182-183 °E during Mar 11-20.
- 1995-004F ODERACS 2D decayed from orbit Mar 2.
- 1995-005A Progress-M 26 undocked from the Mir Complex Mar 15.10 and was de-orbited later that day.
- 1995-006A Foton 7 (Flight 10) was recovered Mar 3.36, landing 135 km south-east of Orenburg. The descent module and the experiments were badly damaged (the ESA Biobox was wrecked and one of the experiments was lost) when the recovery helicopter was forced to drop the re-entry module due to the bad weather conditions at the landing site.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

7 June 1995

7 - 8.30 pm

Magellan Looks at Venus

Prof Dan McKenzie

Department of Earth Sciences,
University of Cambridge

For four years Magellan mapped the whole Venus surface with a resolution of about 100 m. We now have better maps of its surface features and gravity than we do of Earth.

Spectacular images of the surface show how different Venus is from Earth. Though the origin of many of the features is not yet properly understood, the gravity field has already provided some clues. Unlike Earth, the topography of Venus is dominated by mantle up- and downwelling. Perhaps the most important result of the whole mission is that it has shown us that we still have a great deal more to learn before we understand what controls the dynamics of rocky planets.

10 July 1995

7 - 8.30 pm

Australia in Space

J. Heyman

Western Australia

The lecture will commence with a discussion of Australia's early space history, including

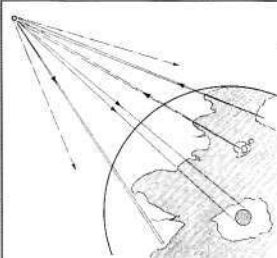
12 August 1995

50th Annual General Meeting

The 50th Annual General Meeting of the Society will be held at The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1, on Saturday, 12 August 1995 at 12 noon.

Admission is by ticket, available to Corporate Members (i.e. Fellows of the Society) only, who should apply in good time enclosing a stamped addressed envelope.

Council nomination forms are obtainable from the Executive Secretary. These must be completed and returned not later than 12 noon on Friday, 19 May 1995. If the number of nominations exceeds the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all Corporate Members.



ENJOY AN EVENING WITH ARTHUR C. CLARKE

at

The Scientific Societies Lecture Theatre,
Fortress House,
New Burlington Place, London W1

at 6.30 pm on 18 August 1995

The Society will present its Space Achievement Medal to
Arthur C. Clarke

in honour of his work, together with a special commemorative plaque to mark the 50th Anniversary of the concept of geostationary satellites advanced by Arthur in 1945.

◆ Buffet Reception

◆ Guest Speaker

Tickets are available to members at £20 per person. Early application should be made to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

the development of Woomera, the sounding rocket programmes conducted at Woomera, the involvement with the British and ELDO space programmes, the cooperation with the US and the launch of Australia's own Wresat satellite.

The lecture will then discuss the limited activities from Wresat until the 90s and will finally have a look at the recent five year space plan promulgated by the Australian Space Council.

6 September 1995

7 - 8.30 pm

STRV Satellites: Mission and Results

Dr Andrew Sims

DRA Farnborough

On 17th June 1994, two small satellites built by the Defence Research Agency were launched from Kourou, French Guyana as auxiliary payloads on Ariane flight V64. Placed into Geostationary Transfer Orbit, the mission of the two 52kg "Space Technology Research Vehicles" is to demonstrate the in-orbit performance of novel technologies and to make supporting measurements of the space environment. The talk will focus upon lessons learned from the new technologies - both during development and in-orbit and on results from a variety of radiation monitors flown on both satellites.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

3 June 1995

10 - 4.30 pm

Soviet/CIS Astronautics

The Soviet/CIS symposium is acknowledged as one of the foremost meetings for the presentation of material on current and historical reviews of the space programmes of the Soviet Union and its successor Republics.

13 September 1995

10 - 4.30 pm

Low-Cost Satellites

Many organisations have been trying to reduce costs substantially, mainly by the innovative design of micro- and minisatellites. Some of the topics relevant to this theme will be presented.

27 March 1996

10 - 4.30 pm

Call for Papers

Space Transportation

For over a decade the BIS has run symposia on the subject of space transportation. These are intended to provide a forum to cover all aspects of the space infrastructure including the rationale for infrastructure development, system concepts and technology issues. In the past these symposia have been key to the development of HOTOL, Skylon, the Polar Platform and UK thinking on space industrialisation as a part of mankind's future.

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CLASSIFIED ADS may be placed by Society members at the rate of 53p per word inc. VAT (non-members £1.06 per word inc. VAT). All classified advertisements must be pre-paid. Cheques and postal orders should be payable to the British Interplanetary Society.

'Microgravity Facilities' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

Mrs M. Stevenson	UK
Mr A. Depuydt	Belgium
Mr H. Gust	Germany

The correct answers are:

1. Glovebox; 2. Biorack; 3. Anthrorack;
4. Critical Point Facility.

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Dr Patrick Moore, CBE
Fellow of the British Interplanetary Society

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*Application constitutes
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Spaceflight

The background of the magazine cover is a photograph of the Mir space station in orbit above Earth. The station's complex structure, including its main module and four large solar panel arrays, is clearly visible against the blue and white clouds of the planet. The station is oriented diagonally across the frame, from the upper left towards the lower right.

The International Magazine of Space and Astronautics

MIR

DOCKING
PLANS
MEET WITH
SUCCESS

SHUTTLE
Florida
Base
Visited

SHUTTLE
Telescopes
in Action

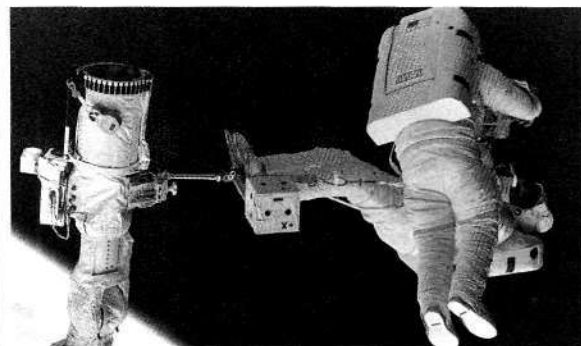
PATRICK MOORE
New Views of Vesta

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NEW !!

STS-63 Mission Highlights

Launch Date: 3 February 1995

The 20th orbital flight of Discovery. The crew included as mission specialists Russian Vladimir G. Titov, Janice Voss and British born C. Michael Foale. The prime objective of the mission, and the first stage in the American-Russian space station programme, was to make a close rendezvous with MIR to test the procedures to be used on Mission STS-71 to dock the shuttle with the space station. STS-63 carried Spacehab-3 science module and the SPARTAN-204 deployable/recoverable astronomy satellite. Other experiments included CSE (Cryo Systems Experiment), GLO-2 (Shuttle Glow Experiment), ODERACS-2 (Orbital Debris Radar Calibration Spheres). The video runs for approximately 1 hour and includes some spectacular rendezvous images of the MIR space station.

STS-65: Mission Highlights

Launch Date: 8 July 1994

STS-65 was the 17th trip into space made by space shuttle Columbia which spent 14 days in orbit. The mission conducted a wide range of experiments concerned with biochemical, biological and human physiological processes in reduced to zero-gravity environments. The science crew included for the first time a Japanese woman as a mission specialist. The second International Microgravity Laboratory (IML2) science programme was made up of a number of experiments ranging from protein separation and electrophoresis, to the study of growth and breeding of fruit-flies in zero to 1G variable-gravity environments. The effects of zero-G on the swimming orientation of goldfish, and the behaviour of adult Japanese Red Bellied newts and the growth of their embryos were among a range of aquatic experiments performed in a special unit called the AAEU (Aquatic Animal Experimental Unit) which was probably the first equivalent of an aquarium in space. The video includes some excellent views of Earth. There is only a limited sound commentary.

57 mins

STS-64: Mission Highlights

Launch Date: 9 September 1994

The 19th flight of Discovery conducted a diverse range of experiments concerned with Earth environment monitoring technology. The mission included the release and recovery of the 2800 pound SPARTAN satellite. The mission included extended EVA activities. Nitrogen propellant recharging of the astronauts' manoeuvring unit, the SAFER (Simplified Aid for EVA Rescue), is shown. Its manoeuvring ability and its attitude control

system are impressively demonstrated. The mission also included a series of atmosphere monitoring experiments with the Lidar in Space Technology Experiment (LITE) instrument.

1 hr 4 mins

STS-60: Mission Highlights

Launch Date: 3 February 1994

This Discovery mission included Russian cosmonaut Sergei Krikalev and marked the start of a new era of USA and Russian cooperation in Space. The mission carried the Spacehab module and a three-dimensional gravitational accelerometer. Other experiments included the study of crystal growth under zero-G, the deployment of BREMSAT and the launch of six Orbital Debris Radar Calibration Spheres (ODERACS), ranging from 5 to 15.2 cm in diameter.

58 mins

STS-59: Mission Highlights

Launch Date: 9 April 1994

Perhaps the most challenging part of this shuttle mission was experiment SRL1, the first flight of the Space Radar Laboratory. To study the surface of the Earth with this instrument package Endeavour was required to make more than 400 separate position manoeuvres to achieve the ground track and orbiter alignment essential for radar mapping the surface and geology of the Earth. Other important tasks included tests of a new form of video-microscope capable of studying biological processes, such as cell growth and movement, under zero-G conditions. Pollution studies included mapping the global and local distributions of CO important in the study of ecology and the ecosphere. There are a number of spectacular SRL1 Earth views.

59 mins

Please send me the following cassette(s): Please Tick

- ☐ STS-63: Mission Highlights
☐ STS-59: Mission Highlights

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Practical Methods for Near-Term Human Exploration of Mars

Exploration of the Future Habitability of Mars

Concepts for In-Situ Resource Utilization on Mars:
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Front Cover: **Approaching the Mir Station as seen from Soyuz TM-20 under the command of Alexandr Viktorenko who skilfully carried out a manual docking during the EuroMir-94 mission in October 1994.**

Supplied courtesy of ESA

BY PETER SMOLDERS, FBIS
The Netherlands

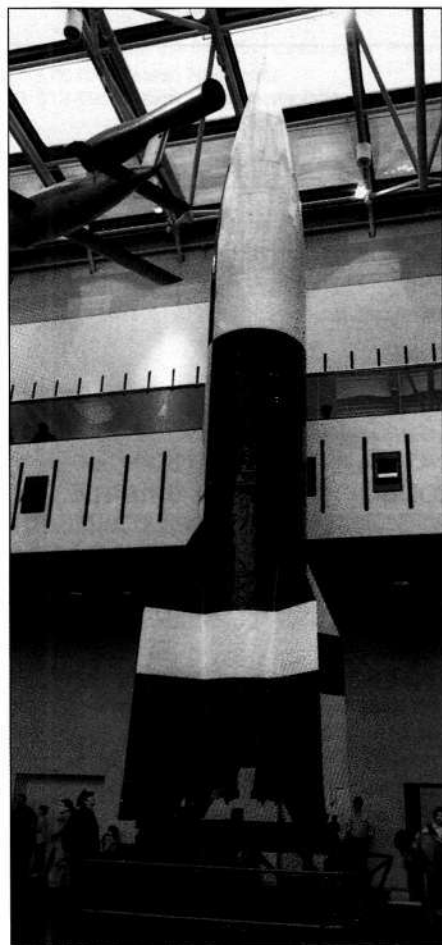


Prof Boris Chertok.

PETER SMOLDERS

V-2 rocket on display in the National Air and Space Museum in Washington.

PETER SMOLDERS



I Meet the Man Who

"Ich spreche Deutsch, aber sehr langsam" ("I speak German, but very slowly"). Indeed, Professor Boris Yevsheyevich Chertok pronounces these words slowly but convincingly. German? Seldom do Russians speak a foreign language, let alone elderly Russians and the man who was sitting in front of me was over eighty.

It was only during our third meeting, that I found out why he speaks German: Boris Chertok was responsible for the top-secret operation "Ost" (East), which started fifty years ago at the end of World War Two: 150 German rocket specialists were "captured" and later transported to Russia to communicate their knowledge of the V-2 and other rocket weapons to the former enemy.

Chertok continued the interview in Russian: "For two years I worked at Bleicherode, a village not far from the underground V-2 factory at Nordhausen. I arrived in Germany just before the 9 May 1945 Victory Day and "saved" the rocketry knowledge and experience of our German friends. It is a detective story about which you can find more in my new book "Rakety i Lyudi" (Rockets and Men) to be published soon.

Chertok started his professional career not in cosmonautics but in rocketplanes. In 1944 he switched to the rocket research institute RNII, where future chief designers Sergei Korolyov and Vladimir Glushko had already been active. But they had been arrested on Stalin's orders in 1938 and transported to a Siberian camp. When Chertok arrived at RNII research was beginning on the V-2 weapons. The Russians had already collected some interesting remains of the secret weapon at a mobile launch site in Poland. They had done this in cooperation with the British after a message from Churchill to Stalin, revealing the existence of the site. Chertok worked together with Vassili Mishin, the man who would become Korolyov's successor after the death of the chief designer in 1966.

Chertok continued: "In April 1944 I was invited to participate in the work of a secret commission and had extensive authority. I travelled in the uni-

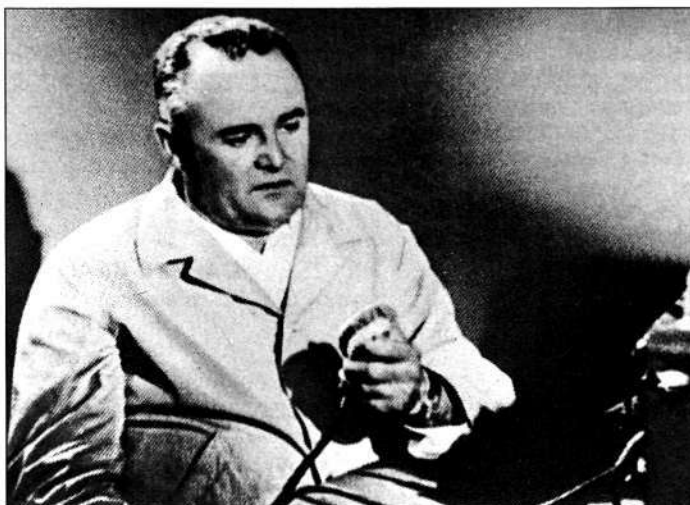
form of a major of the Russian air force first to Berlin and then to Peenemünde, the centre for V-2 research on the isle of Usedom. After that we went to the underground V-2 factory "Mittelwerk" in Nordhausen. We began collecting lots of hardware and German specialists who had not yet fallen into American hands.

"On my initiative in July 1945 we started a *joint venture* in Bleicherode with the Germans, called Rabe (Raven). I became director together with a German specialist. We had dreamt of catching Wernher von Braun, but he appeared to be already firmly in American hands. In October, Korolyov arrived directly from Kazan, where he had been imprisoned. There I met him for the first time. Soon Glushko arrived also.

The Russians had not been able to capture von Braun. Their biggest catch was Helmut Gröttrup, von Braun's right-hand man for guidance and control.

"After working for two years in Bleicherode, the Germans - 500 including families - were transported to Moscow and subsequently to a lovely but heavily guarded island in Seleger Lake between Moscow and Saint Petersburg. Laboratories and test stands were built, reasonable housing was provided and Russians and Germans jointly launched reassembled V-2's on the new launch site Kapustin Yar near Stalingrad. The cooperation

All the early space firsts were achieved by space vehicles designed and constructed under the guidance of Sergei Korolyov.



Brought the V-2 to Russia

ended when the Russians could learn nothing more from the Germans. The Germans were not involved in the development of a Russian follow-on to the V-2: the R-1 rocket. In 1953 the Germans were allowed to go home. In 1954 Gröttrup and his family returned to the DDR."

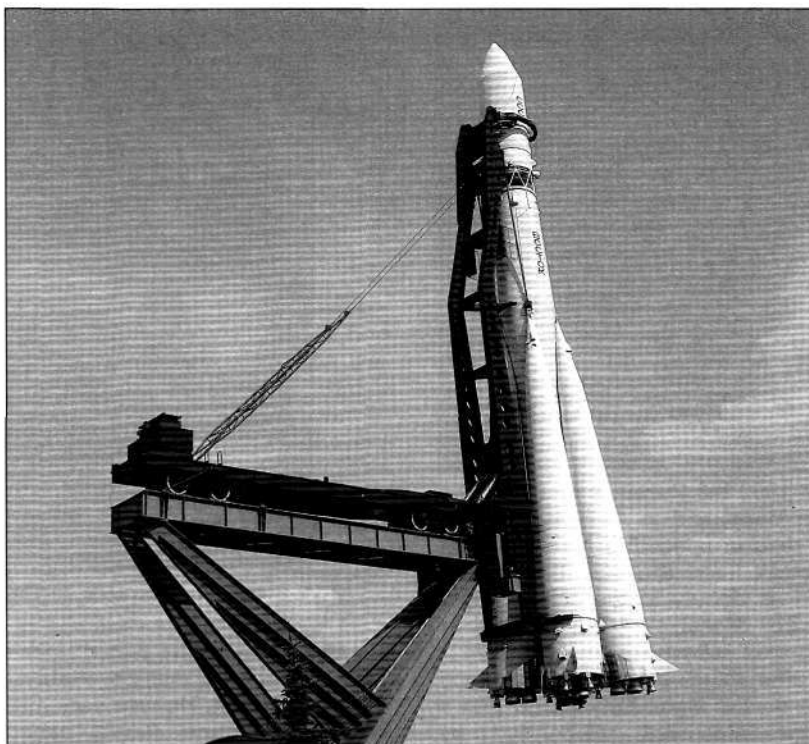
"Their return turned out to be rather tragic", said Chertok. "I only heard about this not long ago. After having published an account in *Izvestia* about my adventures in Germany I received a message that Gröttrup's daughter Ursula wanted to see me. We met in Moscow and I asked her how she had found me. It turned out that a German girl in Hamburg read *Izvestia* and she worked with Ursula at the same institute. So they called from Hamburg to the editors of the newspaper and were given my telephone number. So Ursula came to Moscow.

"She told me that she wanted to visit the island where she had lived with her parents when she was a little girl. The island is now closed up, although no rocket research goes on there any more. I could not help her. But with a few bottles of vodka and some dollars she managed to get in. She told me that later when I met her again - this time in Germany.

"The Gröttrup's had expected to be well received in the DDR. But when they arrived at the East Berlin railway station they were not met by DDR secret service men, as they had expected, but by American agents from West Berlin. They showed documents proving that passports had been organised - with DDR consent - to the Western zone. The DDR did not want to see them. "You should come with us in our car to West Berlin", the Americans said. Then they went from West Berlin in a jeep to Munich, where they were interrogated about what they had done in the Soviet Union. They were offered a contract to work in the US in the field of rocket research. But Gröttrup's wife Irmgard insisted she never wanted to leave Germany again and two hours later they were thrown into the street with their luggage.

"For some time they lived in very poor conditions and thought nostalgically about our beautiful island. At last Helmut found work in electronics and computers. He invented a machine to count banknotes. For that he received quite a lot of money and could buy a good house and improve their situation. But his success was not long-lived: soon he developed cancer and died.

"His wife thought of ways to make money and soon after the launch of the first Sputnik she published her



R-7 or "Semyorka" (Number Seven), the workhorse of the Soviet-Russian space programme from the first Sputnik to the Soyuz manned spaceships.

PETER SMOLDERS

memoirs about life in the Soviet Union with her husband among the people who were dedicating their lives to conquering the cosmos. In this way the family could go on living."

For twenty years Chertok worked side by side with the legendary chief designer Korolyov as his deputy for guidance systems. Chertok continued: "Korolyov was unique. He had the talent to understand quickly - within a few minutes - whom he was dealing with. Also he was an excellent organiser. He had a fast mind and was strong willed. That is very important for someone who organises big and complicated projects. He did not like to be bothered with too many details. He understood what a big system is all about. He developed a strategy for the new technology. He did not only see today's goals, but also those of many years ahead. Sometimes others perceived his ideas as mere fantasies.

"In 1957 we launched on his *personal initiative* the first satellite using a military rocket, the R-7. This rocket was not developed to launch a Sputnik, but to carry a nuclear warhead to the US. But Korolyov immediately started to lean on the defence people: "Look guys, we are of course not going to throw bombs at the Americans, so let's put a satellite on top of it." They did not object. That was it. And in 1961, with the same booster we launched a human being for the first time, although no one had thought about it when the rocket was being designed and built. But he thought of

it and decided it was possible. In this way he distinguished himself from others."

"The world's reaction to the first Sputnik was not foreseen by the Soviet leaders, including Nikita Khrushchev. Immediately after the launch Korolyov and his closest associates travelled to the Crimea for a short rest after eight years of uninterrupted work. But shortly after their arrival they were called back to the Kremlin. At the beginning of November the 40th anniversary of the revolution was to be celebrated and the

Vassili Mishin, the successor of Sergei Korolyov in discussion at the World Space Congress, Washington DC in 1992.

THEO PIRARD



now enthusiastic Khrushchev wanted another space success. Korolyov proposed to launch a dog. Within a record period of three weeks the whole project was realised and Laika orbited the Earth in Sputnik-2." "Imagine," Chertok smiled, "Nowadays scientific projects in space typically have a lead time of ten years - if they don't die prematurely."

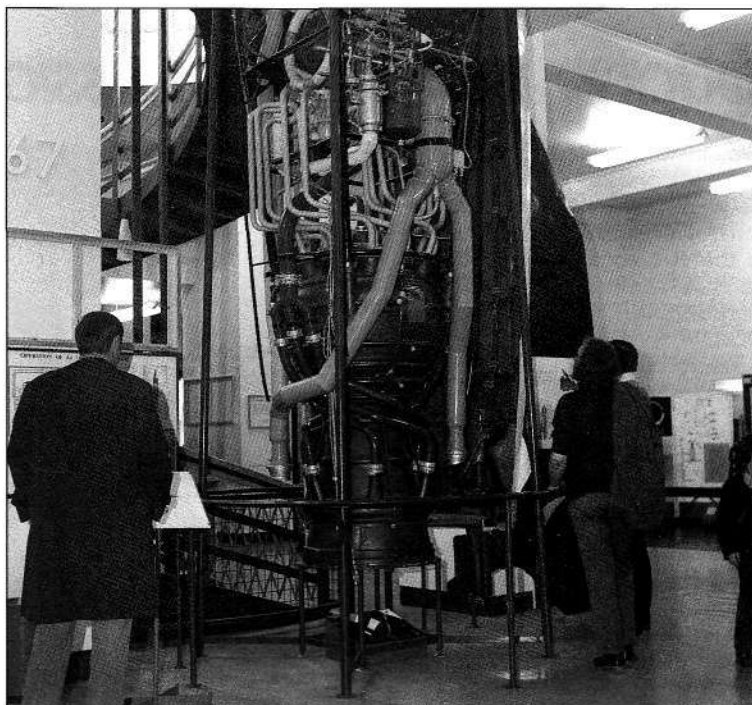
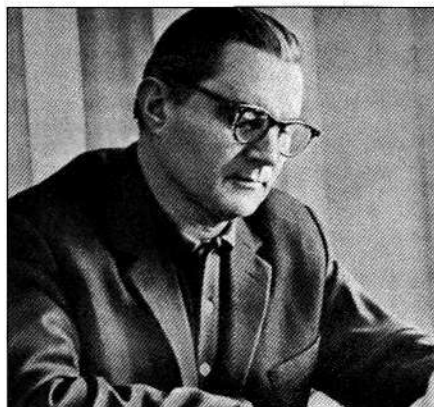
"All early space firsts were Korolyov's: The first Sputnik, the first living thing in space, the first human space traveller, the first woman in space, the first space walk, the first object on the Moon, the first lunar satellite, the first soft landing on the Moon, the first spacecraft to Venus and Mars. But when Korolyov died suddenly in 1966 on the operating table, Soviet cosmonautics suddenly appeared to be in trouble. In 1967 cosmonaut Komarov crashed during landing, in 1969 the Russians lost the race to the Moon and in 1971 three Russians died in space."

Chertok lived through it all as he served as deputy to the chief designers after Korolyov. Chief designer Mishin was relieved of his position in 1974 after the Russian project to land a man on the Moon had turned into a disaster. He was succeeded by Valentin Glushko, who finally cancelled the N1/L3 lunar project and started developing a new heavy booster, later to be called Energiya.

"Was it right to end the work on the lunar rocket N-1 and the single person moonlander L-3?", I asked.

Chertok continued: "This is a very complicated question which we could discuss for hours. There were many pros and cons. In our country we lacked a good detailed programme for the use of space and the Moon. There was no political advantage in continuing to go to the Moon, because the Americans had already been there six times. If we had stepped on the Moon even once after that, nobody would have been particularly happy. Also scientifically it would have added nothing. So it would have been necessary to plan a new programme - build a real lunar outpost - and that would have been very costly. The political leaders then in power were not prepared to go along with that. If Khrushchev had

Valentin Glushko, rocket engine designer.



V-2 engine, to be seen in the Science Museum in London.

PETER SMOLDERS

still been around (he was dismissed in 1964), he would most probably have decided to do it. He was very much in favour of space flight, especially manned space flight. He saw space as a very powerful political and propaganda tool."

Then I asked, "What about the new booster Energiya and your space shuttle Buran to which you also contributed? Those projects were stopped too, after years of devoted labour. Was not that very frustrating?"

Chertok continued: "Here it was different. Everything worked fine technically, while in the N-1/L-3 project we had made serious mistakes. Energiya-Buran was a success technically speaking. On the first flight the system performed excellently, even in the unmanned mode. But economically speaking it was just like the American shuttle. Economically the space shuttle turned out to be less attractive than expendable rockets. In this respect we did no better than the Americans, only in the sense that we achieved an automatic landing and in this we surpassed them. Regrettably this does not mean anything in economic terms. Both we and the Americans had originally expected the shuttle to perform cheaper than expendable boosters, but it turned out to be more expensive."

Chertok still does not think about retiring. Every day he still travels from Moscow to Korolyov's firm RKK Energiya in Kaliningrad to work on a project of a more modest calibre, namely communication systems using small low Earth-orbit satellites.

"These are systems with which we can connect anybody to anybody: you sit in Holland and I here in Moscow and we can talk via a hand-held little device. For the time being without

visuals, but later also with television and telefax. So it would not be necessary to meet in the flesh for this conversation, for which you came all the way from Holland. The only limitation is that you could not offer me a glass of vodka, but each would have to bring his own bottle. Such a project both culturally and economically would be of the utmost significance for mankind. But politics and capitalistic competition are in the way so far."

"Why do you have such interest in the field of communications?", I enquired.

Chertok ended the conversation by replying: "Radio is my first love. For the few years left to me I decided not to be involved in huge projects, but to do something useful and still be able to see the results of it. I am convinced that in this area we can do something beneficial if only we can manage to pull in the money." ■

Prof Chertok's Book

"Rockets and Men"

Professor Boris Chertok (83), one of the very few remaining pioneers of the Soviet-Russian space programme, recently published his book "Rakety i Lyudi" (Rockets and Men) in which he tells the story of the development of rockets and space flight as he experienced it first hand in the forties and fifties. The book ends with an account of the construction of the Baikonur (Tyuratam) launch site. In a second volume (still to be published) he will deal with the sixties and seventies, including the race to the Moon.

I strongly feel that both volumes should be translated into English: they are of immense value to anyone interested in the history of space flight. Any interested publisher is invited to contact me: Peter Smolders, c/o The *Spaceflight* Office.

Mir Docking Plans Meet With Success

On 16 March cosmonauts Vladimir Dezhurov, Gennadi Strekalov and American physician and NASA astronaut Norman Thagard ("the Hurricanes") boarded Mir to continue its permanent manning. Thagard was scheduled to set a new endurance record for an American and the mission is to include the arrival of the American space shuttle orbiter Atlantis.

The two Russian cosmonauts faced a heavy schedule of work, including EVAs, before the American orbiter arrived and the mission was soon extended past the originally planned date to accommodate a delay to the launch of Spektr.

Orbital Routine

The routine on Mir closely resembles the working day in Moscow, beginning at 8 am Moscow time. The first two hours are reserved for the cosmonauts to wash, eat breakfast, and prepare for the day's work, which runs from 10 am - 7 pm, with breaks for lunch and exercise for each crew member. After dinner, the crew prepares its reports on the day's activities and reviews the plan for the next work-day. From 10 pm - 11 pm, the crew members have personal time, followed by the start of their nine-hour sleep period. The schedule would be altered for events such as the arrivals of the Progress and Spektr modules and the scheduled spacewalks in May.

NASA called the work schedule "fairly light", but the momentum would pick up the following week when the crew were to begin collecting blood, urine, and body fluid samples as well as tracking their food, fluid, and drug intake to look at microgravity-induced changes to the body's metabolism. A tracer protocol would use bromide, traceable water and glycerine. The bromide would be used to monitor changes in the amount of extracellular fluid. The traceable water would track changes in total body water, and glycerine would be used to monitor muscle turnover. The tracer protocol would then be repeated twice more during the crew's stay.

Seven experiments focusing on the metabolic/regulatory system were scheduled to be performed during the Mir-18 mission which would examine the nature and extent of fluid shift that occurs in orbit; calcium absorption as it relates to the loss of bone mass; factors which may influence the formation of kidney stones; the effects of exercise on metabolism; changes in red blood cell composition and production; and changes in the reaction to standard pharmaceuticals used in long-duration space flight. The sample collection on Mir would be supplemented by samples to be collected during STS-71.

During 24 March Thagard was able to show, through video pictures beamed to the Houston Mission Control Centre, just what life was like for him on Mir.

"So far, things are going pretty well," Thagard said, noting that his projected three-month stay was not long by Russian standards. It was im-

BY NEVILLE KIDGER FBIS

Leeds, UK

portant to feel at home and his bed was in "the quietest place in the station". His only complaint was that it lacked "good radiation protection."

Unlike shuttle missions, where every day is packed with work, "a weekend here on Mir is considered to be a weekend", he said.

The cosmonauts spent the weekends relaxing and also cleaning the walls of the station. There was even time to use the station's shower facility. The shower cubicle, located in the Kvant-2 module, had ceased to be used as a shower and the cosmonauts used it as a sauna as TV shots of Dr Valeri Polyakov using the cubicle had shown.

Flight Control Simulations

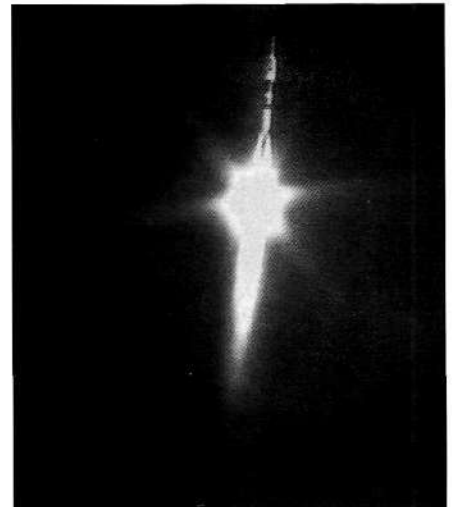
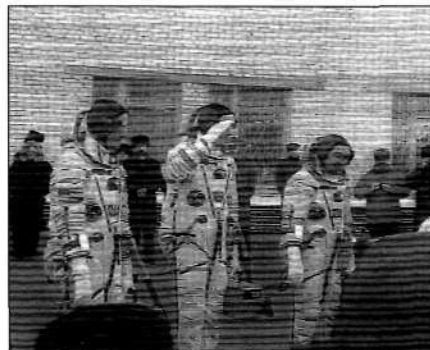
As March ended, flight controllers in the United States and Russia were practising the latest in a series of joint simulations of the STS-71 mission that was scheduled to conclude the three-month flight. The exercise was designed to refine coordination between the two control centres in Kaliningrad and Houston and rehearse portions of the mission's timeline.

On 29 March, Dezhurov and Strekalov begin a three-day maintenance procedure to change a condenser in the station's air conditioning system as part of a larger maintenance plan to prolong the life of the station.

Thagard told the American CNN news network on 31 March that he was content to keep working on Mir despite the uncertainty about his return date. He said that he could handle any delay although he agreed that

The Mir-18 crew walkout on 14 March.

NASA



The launch of Soyuz TM-21 on 14 March with the M-18 crew of Dezhurov, Strekalov and Thagard.

NASA

it would be nice to return to Earth on schedule.

"I came here prepared, in case Atlantis didn't launch at all, to get in our Soyuz in August and come home if that were necessary," Thagard said. "If it gets delayed, what choice do I have?"

Heart Studies

Upon entry into space, body fluids migrate from the lower extremities to the upper torso and heart. The extra fluid around the heart causes the body to employ natural processes to eliminate what it perceives to be excess water. The cardiovascular system can subsequently become deconditioned during an extended stay in space.

By drawing fluid back down to the lower extremities and exercising the heart, the condition of the cardiovascular system can be improved. Applying negative pressure to the lower body achieves this effect.

The subject puts on a device - the Chibis suit - which seals at the waist. A partial vacuum which is incrementally induced, draws the fluid to the lower extremities. All three crew members were to serve as Chibis suit subjects three times during the Mir-18 mission. Thagard spent about 30 minutes in the Chibis suit.

On 3 April Thagard's efforts were directed towards preparation of the PILOT experiment, designed to evaluate a person's visual perception and motor dexterity control. The PILOT system uses computer equipment and displays to allow the operator to fly simulated approach-and-dockings to the Mir station. The system resembles the one used by Shuttle pilots during long missions to maintain their approach-and-landing skills. The next day he made several runs on the docking simulator and noted a great deal of difference between the PILOT system used on the ground for training and

MIR MISSION REPORT

the one used in flight. The onboard system seemed to have more sensitivity to fine course correction inputs but the visual display seemed to be of lower quality. Additional runs of the PILOT system were scheduled for later in the flight.

On the morning of 7 April, Thagard conducted a television broadcast from Mir describing activities and accomplishments of the Mir-18 crew. He was interviewed by a Philadelphia TV station.

Progress M-27 in Flight

On 9 April, Progress M-27 was launched on time at 1934 GMT aboard a Soyuz U carrier rocket. It carried a 2.4 tonne payload which included 400 kg of food, 500 kg of fuel and a tonne of scientific equipment for the crew. The equipment aboard included various kits, logbooks, observation materials, glovebags, greenhouse fixative, and harvesting materials. All items were part of the fundamental biology work being done on Mir.

Progress was also to deliver a Mir Grab Sample Container with which air samples would be taken in support of environmental monitoring and it was to deliver blood and urine collection kits for the metabolic research effort.

During 11 April, activities aboard the station were fairly light. The crew spent part of the day with preparations for the arrival of the Progress cargo craft.

The next day was a special one aboard the complex with activities planned to celebrate Cosmonautics Day in space and across Russia. The crew spent part of the day participating in two in-flight press conferences. The first from the TsUP Mission Control Centre, Moscow with the Russian news media and the second with the US media at the Johnson Space Center in Houston and the Kennedy Space Center in Florida. But first there was the docking of the unmanned cargo craft to oversee.

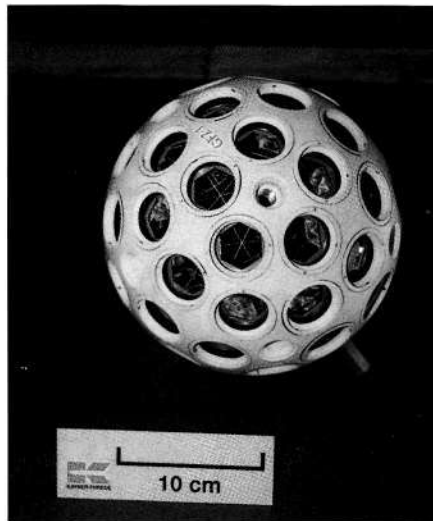
Progress M-27 Docking

A close approach command was conducted from TsUP at about 1930 GMT on 11 April to bring the Progress towards the complex. TV of the complex was returned from the unmanned craft.

In view of the recent spate of Kurs rendezvous system malfunctions, the Russians stressed that Dezhurov had trained to manually dock the cargo ship using remote commands should the automatic approach and docking system fail.

However, a flawless docking occurred at 2101 GMT using the automated system at the front of the base block.

The cosmonauts were unable to view the approach via TV aboard Mir because of a communications fault and ground controllers relayed data to the flight crew to help them monitor



GFZ-1.

KAYSER-THREDE

the approach. Thagard used a video camera to record the approach and docking. Thagard later described the experience as "exhilarating". The docking was without sound and very smooth, he reported.

The crew, who were allowed to schedule their own day on 12 April, soon opened the 25 kg of personal packages which had been loaded into Progress. They celebrated the arrival with lollipops!

Press Conference Insights

During the 12 April conferences, the press was able to learn much about the stay of Thagard aboard the Mir complex. For the Americans it was their first chance to talk with an astronaut staying in space for longer than two weeks since the 1974 Skylab-4 mission.

Thagard revealed that the flight of Yuri Gagarin was one of the reasons he applied to become an astronaut. The doctor was a student at the time of the 1961 mission but remembered the event well.

Answering questions in Russian, he said that he felt as though he had fully adapted to the microgravity in space during this flight. During his previous missions on the shuttle he had never fully adapted to weightlessness but he now felt as he did on Earth but without the pull of gravity.

He told reporters that he had collected almost 10 kg of urine during the science experiments but did not know where to store the containers. Some were kept in the ESA freezer. The doctor gave insights into the problems of storage space on the Mir complex. It was noted that on occasions the cosmonauts in space had to request the TsUP to ask previous tenants of the complex where certain items were stored. Not all of the locations of equipment and devices were logged on the complex's computers.

Waste disposal was also a problem, Thagard noted. He said that he would have many recommendations to report at the end of the flight which he hoped would be used by the designers of the

International Space Station.

Thagard admitted that he missed news from America, saying that he often heard snatches of Russian reports but his only access to other news was via the Mir's ham radio system.

The three men's spare time was taken up listening to music and watching videos of American, Russian and German movies.

Strekalov said that there were good relations throughout the crew and that Thagard was a good, hard-working astronaut. However, Thagard said that he was in an isolated environment and had to keep track of time, but he relented: "I'm having the time of my life, really."

Incubator Experiment Begins

On Thursday 13 April, in addition to unloading items from Progress M27, the crew set up and checked out the incubator system to support the Japanese quail egg experiment. The 48 quail eggs, which were part of the Progress M-27 payload, were fertilized shortly before launch.

Each of the eggs was to be fixed at various points in the flight to allow researchers to examine how the developmental process is affected by weightless conditions. Nine of the eggs for the Mir 18 experiments were to be developed to full term and all the samples would return aboard Atlantis.

On 14 April the crew participated in two educational events. The crew spoke to students associated with the GLOBE (Global Learning and Observations to Benefit the Environment) project - an international partnership programme that involves students and schools from different countries conducting scientific investigations and monitoring the Earth's environment. The students spoke to the crew from TsUP and NASA Headquarters in Washington, DC.

Shower Removed and Microsat Released

Dezhurov and Strekalov began the removal, on 18 April, of the shower in the Kvant 2 module to make room for the installation of a set of gyrodynes to support the docking of Atlantis.

The crew reported that they did not have the correct tools for the removal and they resorted to using a hammer. The shower had not been used as such for about two years, being used only as a sauna. According to NASA it would not be missed. During the day Dezhurov and Strekalov worked on disassembling and removing the shower. This involved cutting the shower cabin into smaller pieces so it would fit into the Progress craft.

The next day Thagard was scheduled to perform more tests with the PILOT system. Also on 19 April Thagard gave a televised status report of the Mir-18 crew's efforts to date

and discussed upcoming activities in preparation for the arrival of the Spektr science module. The day's activities also included exercise and the planned deployment by a spring system out of the Mir base block waste airlock of a small German geodetic satellite.

The German satellite was delivered by Progress M-27. Designated GFZ-1, the laser geodetic satellite had a diameter of 215 mm and weighed 20 kg. Equipped with 60 reflectors it would be targeted by laser stations in Germany, the UK and Austria.

EVA's Delayed

On 19 April, NASA reported that the first two EVAs, scheduled for 28 April and 8 May had been rescheduled for no earlier than 9 May due to the extension of the mission and the Spektr launch delay.

Thagard defrosted the ESA freezer on 23 April and performed egg fixation activities for the Incubator experiment the same day. NASA reported that two sets of eight eggs remained to be fixed.

On 26 April, Thagard reported that the temperature of the ESA freezer signified that it needed to be defrosted again and the freezer was shut down, as planned. Urine and saliva samples would remain in the freezer temporarily, while blood samples were stored in the TEF. In addition, Thagard reported that some of the 16 fixated eggs had been smashed by a divider in the fixation kit. The damage to the eggs was not known but the divider was to be removed from future kits to allow more space for the eggs.

Dates Confirmed

During 27 April the official dates for the Spektr launch and the EVAs were relayed to the crew. The first two EVAs would occur on 12 and 17 May. Spektr would launch from Baikonur on 20 May, with EVA 3 on 24 May. Spektr would dock with the complex on 26 May with hatch opening scheduled for three days later. A fourth EVA would be scheduled after Spektr was safely attached to the Mir.

Although there were no scheduled science activities for 28 April NASA

gave specific data relayed from Thagard regarding the Incubator experiment. During the evening's air-to-ground communications session, Thagard said that the eight egg fixations had been completed for day 14 and spoke with an AMES Fundamental Biology representative about the Incubator experiment. During 29 April, which was day 16 of the Incubator experiment, Thagard completed the fourth and final fixation of eggs.

On 2 May, the two Russian cosmonauts began EVA preparation activities and taking an inventory of all the connectors and cables that would be required for the EVA. During 4 May, EVA preparations continued with the assembly of power cables electrically linking the Kvant and Kristall modules. The cables were to connect the solar array of Kristall following its move during EVA-2 to the Kristall power system. The batteries of Kristall were not being moved and would be powered by the array once it was mounted on the Kvant module.

Strekalov Hand Injury

During 5 May, ITAR-TASS revealed that mission controllers had been trouble-shooting a medical problem with Gennadi Strekalov over the previous few days as the flight engineer had earlier injured a hand whilst cleaning the wall of the station.

In attempting to reach behind a panel he had caught his hand on a loose object and scratched it. The injury soon became inflamed causing concern about Strekalov's ability to perform the planned EVA.

Medical specialists held group discussions using downlinked video of the injury and prescribed the necessary medication which Thagard administered. The injury had cleared up, Strekalov said, and journalists noted no visible scar or damage to the cosmonaut's hand during the TV relay.

At TsUP Mission Director Vladimir Solovyov said that had the treatment failed the consequences could have been serious: "The crew has a very crowded work schedule for May and June....It is very tense...None of its points must be skipped."

EVA Preparations Continue

On 8 May, officially a day of rest in preparation for the EVA, the cosmonauts spent part of the day packing used equipment and rubbish into the Progress cargo craft for disposal. The undocking and de-orbiting of Progress was expected on 21 May - the day after the launch of the Spektr module.

TsUP controllers advised the cosmonauts that the plan for EVAs had been finalised and had an expected duration of 5 hours 20 minutes. Dezhurov and Strekalov checked the seals on their space suits and continued their preparations for the EVA which on 10 May included a simulation of the EVA with all the spacesuit systems being tested



Thagard and Strekalov on 14 April. NASA

in the base block's docking adapter. A problem with a radio transmitter in one suit was noted and the transmitter was successfully replaced, along with a battery change. On 11 May no scheduled science activities were performed and all air-to-ground communications concerned the upcoming EVA.

EVA-1 on 12 May

The EVA began with hatch opening at 0420 (all times GMT). Whilst Dezhurov, making his first EVA, and Strekalov, making his second, ventured outside the complex, Thagard remained inside receiving commands from TsUP.

The primary activity for the EVA was to ensure the retraction of the Kristall module reusable solar panel (MSB-4). According to the plan the two cosmonauts transferred from the Kvant-2 airlock to the Kvant astrophysics module upon which the panel was to be mounted. They used the telescopic jib erected by Afanasyev and Manarov in 1991 for the traverse.

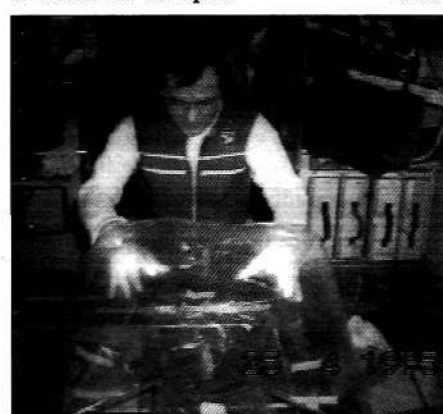
Once at the Kvant module they began connecting the complex's power supply systems to the actuator. Frames for the installation of the solar arrays from Kristall had been erected on the sides of the Kvant module on previous EVAs.

The cosmonauts soon deviated from the timeline and the EVA began to over run. Once their work was finished at the Kvant module they moved to the Kristall module itself. Upon commands from the TsUP the solar panel was folded in three sections as the cosmonauts watched.

A back-up procedure existed in the event of a failure of the MSB-4 retraction by automatic means. This involved Thagard commanding the operation from the Mir base block's central control station.

The cosmonauts eventually returned to the Kvant-2 airlock and closed the hatch at 1035 GMT giving a duration of 6 hours and 15 minutes. However, NASA PAO staff gave a time of 6 hours and 8 minutes in their science report. It was later admitted that the cosmonauts had been forced to miss some of their scheduled activities during the EVA and that these would now be completed during the second EVA.

Strekalov demonstrates the use of the Glovebox on 25 April. NASA



EVA-2 on 17 May

The hatch of the Kvant-2 airlock opened for the second time at 0238 GMT on 17 May, earlier than planned on the timeline. The task for Dezhurov and Strekalov was to remove and relocate the solar array MSB-4 and to complete their unfinished tasks from EVA-1. However, the cosmonauts encountered trouble in moving and locating the array causing a slippage of the timeline. TsUP gave the cosmonauts permission to continue their work past the scheduled completion time of 0812 GMT.

The work to attach the folded solar array was tiring and before the cosmonauts could electrically link the array to the Kvant module the station developed power problems which, according to the Russians, required a switch to the autonomous power supplies of the Soyuz TM and Progress M craft and the switching off of several Mir life-support systems temporarily, including oxygen supply, moisture removal and carbon dioxide removal. Vera Medvedkova, a spokesperson at TsUP told reporters that the cosmonauts had been recalled after they had experienced problems.

"It turned out some things took longer than planned, others had to be modified, and the cosmonauts did not have anyone to consult with," she said. "They had to figure out everything on their own."

Medvedkova was referring to the time that the complex was outside of the radio and TV communications zones over Russia where the cosmonauts were literally on their own and unable to contact TsUP.

The cosmonauts said that they had attached the solar array to the bracket on the Kvant using just the lanyards and straps used to prevent tools from floating away. The EVA had lasted 6 hours and 30 minutes.

On 18 May ITAR-TASS reported that the programme of work for the cosmonauts had been changed and that the next EVA (designated EVA-2B according to US sources) was postponed two days to May 22 to allow the exhausted cosmonauts more time to recuperate. There was concern particularly for 54 year old flight engineer Gennadi Strekalov.

The other EVAs, now scheduled for 24 and 27 May, would see the two cosmonauts move the Konus docking adapter from one radial port to another as part of the operation to move the Kristall module from the -Y port to the -Z port of the base block multiple docking unit. Kristall was scheduled to be moved to the -Z port.

Spektr is Launched

The long-awaited launch of the fourth add-on module for the Mir complex took place from Baikonur cosmodrome on 20 May, at 0333 GMT. The Proton-K rocket placed the Spektr geophysical research module into an

initial orbit of 337 x 221 km, period 89.8 minutes. The craft was to be manoeuvred to dock on 1 June with the -X (front axial) port of the Mir complex.

The 23.5 tonne module, with four solar panels, was a vital requirement for the future of the complex. There was concern that the module would not dock at the first attempt but Spektr was capable of flying autonomously for 90 days.

Of the module's launch weight some 1.7 tonnes was fuel and about 800 kg was American science equipment to be used by Thagard in his studies.

Late on 20 May Spektr was commanded to conduct two orbital correction burns. One pair of the module's solar arrays had been unfurled for power generation. The second pair was to be opened following the docking.

EVA-2B on 22 May

Following EVA-2 the cosmonauts dried out their spacesuits and refilled the suit water tanks and assembled and checked out the TORU equipment. They checked various valves, pressurised the 189 kg Orlan EVA suits to check the seals, and changed consumables including moisture collectors and batteries.

With hatch opening at 00:10 GMT the third EVA was scheduled to last for 6 hours and 15 minutes. Making their way by means of the telescopic crane to the Kvant astrophysics module they set about electrically connecting the MSB-4 solar array. Working with speed they accomplished the connection and under the command of Thagard the array was unfurled as they watched. Electricity was soon being generated.

Returning to the Kristall module the two cosmonauts observed the second solar array, MSB-2, on the Kristall module being retracted in order to provide clearance for the rotation and re-docking of the Kristall module. Thirteen of the panels of the second solar array were retracted during the operation leaving approximately 60% of the solar array still capable of producing power.

Dezhurov and Strekalov returned to the Kvant-2 airlock at 0525 GMT closing out a 5 hour 15 minute EVA which paved the way for the start of the reconfiguration of the Kristall module and the arrival of Spektr.

Progress M-27 Departs

At 2340 GMT on 22 May the unmanned Progress M-27 cargo spacecraft was commanded to undock by the cosmonauts. The craft did not carry a Raduga recoverable capsule and was therefore to be destroyed over the Pacific Ocean some 3,600 km south-east of the New Zealand capital Wellington. ITAR-TASS said this area was a permanent destruction site for Russian spacecraft.

The de-orbit burn was controlled by

the TsUP at 0327 GMT 23 May and the Progress M craft ceased to exist. Meanwhile Spektr was still being manoeuvred by TsUP to rendezvous with Mir. Two more orbit corrections were commanded on 23 May.

Reconfiguring the Complex

The remaining two EVAs were scheduled to last about 40 minutes each to move a passive docking target, Konus, for use during the various module movements prior to and just after the docking of Spektr. Two of the modules - Kristall and Kvant-2 - would be temporarily shutdown so that the multiple docking adaptor located on that end of the space station could be used as an airlock for the two spacewalkers.

During 24 and 25 May the crew continued preparations for the EVAs. Several orbit adjustment burns had been completed aboard the Spektr module with several remaining to fine tune its orbit to closely match that of Mir leading toward the planned docking early on 1 June. Another burn was conducted during the evening of 26 May.

NASA reported that discussions were underway at TsUP on the benefits of retracting the second Kristall solar array, MSB-2, fully. During one communications session with the crew, Strekalov radioed that the array could be retracted without an EVA because he could monitor progress from a window on the station. The partial retraction, accomplished during the third spacewalk, allowed additional power generation prior to Spektr's arrival.

Kristall is Moved

At 2328 GMT on 26 May the Kristall module was undocked from the -Y (lower lateral) port and swung to the -X port (front axial) by means of the small robotic manipulator arm located on the module. The operation was commanded by Vladimir Dezhurov and took about 30 minutes.

EVA-4 on 28 May

Dezhurov and Strekalov's next EVA was a 21 minute exercise in the depressurised docking adapter of the base block when they moved the Konus docking adapter from the -Y port to the -Z port.

ITAR-TASS noted that to qualify as an EVA under the rules of the International Astronautical Federation one part of the cosmonauts' anatomy would need to cross the edge of the egress hatch and no such activity was planned outside the depressurised airlock.

Although there were no specifics given in this regard by the Russians or NASA the news agency noted that the cosmonauts were being paid under a contract the sum of \$1000 per EVA. Therefore, the agency said, the cosmonauts would need to "make a

'space walk' with at least one leg not to lose money."

Kristall Relocated Again

Early on 30 May Dezhurov completed the transfer of the Kristall module using the remote control system and the manipulator arm to move the massive module from the front -X port to the side -Z port.

The operation was interrupted by automatic software when hydraulic connections were not making proper connections. The automatic software made corrections and re-attempted the mating twice before a successful docking was achieved. All was now ready for the docking of the Spektr module.

Module History Made

Observers of the Russian/Soviet space programme were interested to see if a module could be docked with Mir at the first attempt - something that had not been achieved before in the history of the complex.

The Kvant astrophysics module (Module 37 KE) experienced the first of these failures on 5 April 1987. Kvant passed just 10 m away from a collision with the base block. The second attempt, on 9 April, soft-docked with the rear port of the base block but a hard dock was not achieved until an EVA was performed, on April 11, by Yuri Romanenko and Aleksandr Laveikin. They removed a piece of cloth caught on the docking probe enabling a hard dock.

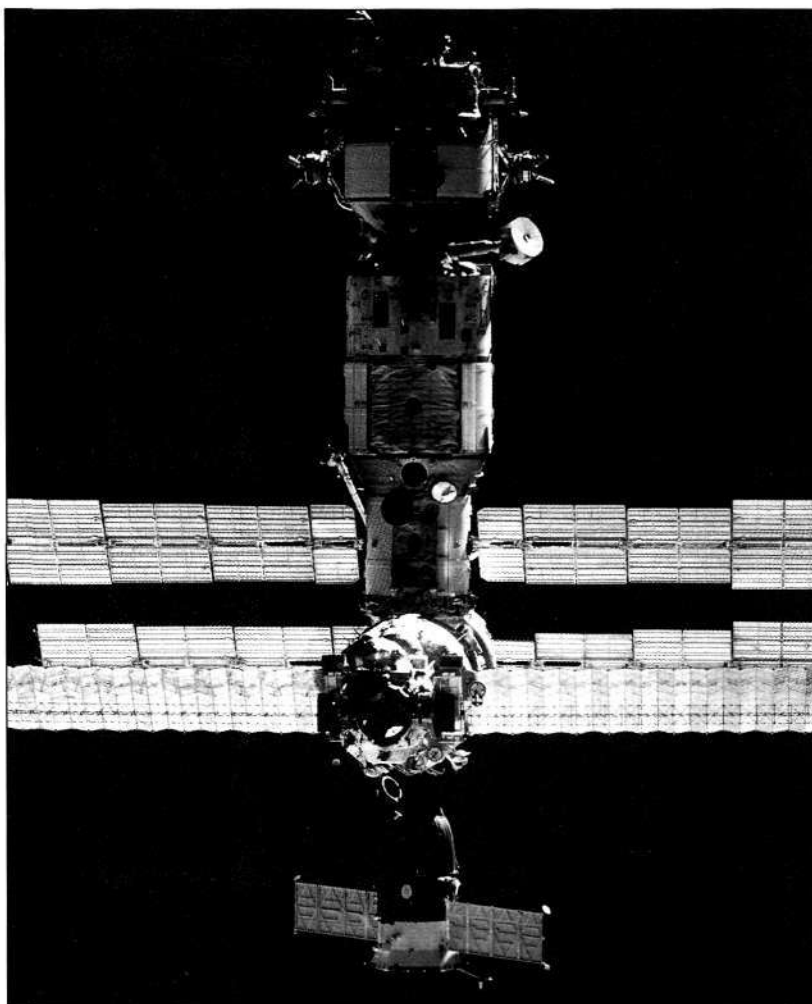
The Kvant-2 Module (Module 77KSD) had the initial docking postponed on 2 December 1989, due to problems with the Kurs docking system. It hard-docked with the front axial port of Mir on 6 December and transferred to the +Y port on 8 December where it has remained ever since.

The Kristall module (Module 77KST) experienced a rendezvous failure which halted the docking on 6 June 1990 because of an engine malfunction. The technology module docked with the -X port on 10 June and was transferred to the -Y port on 11 June.

The Spektr module (Module 77KSO) carried upgraded avionics and the TORU TV system, of the type used by Yuri Malenchenko to dock the recalcitrant Progress M-24 craft in September 1994, to try and ensure that there were no such problems on its docking scheduled for 0047 on 1 June. In the event of failure on the first attempt there would be one more attempt on June 1 also in the automated mode. A manual docking controlled by Dezhurov was to be attempted on 2 June in the event of both the first attempts failing, the Russians said.

Spektr Docks

The Spektr module was able to dock automatically, at the first attempt, at 0056 on 1 June provoking jubilation



This close-up of Mir shows the large Kristall module solar panels which are notable for many concertina-like folds. The EVA activities had the primary aim of retracting the left solar panel and transferring it to the Kvant module at the top of the photo. The two brackets on the sides of the Kvant module to which the solar panels are to be attached are very well displayed.

Supplied courtesy of ESA

amongst controllers. The module had a mass of about 19.34 tonnes when it docked having used up the rest of the launch mass - fuel in its tanks - during the manoeuvres to approach the complex. Discrepancies in quoted masses of the module by ITAR-TASS are unresolved at this writing.

EVA-5 on 1-2 June

After the successful re-docking of the Kristall module, TsUP reported the detection of a small cabin leak. The leak was apparently in one of the seals on the -Z port of the docking module where Kristall was docked. The leak was sealed successfully.

On the evening of 1 June (GMT) Dezhurov and Strekalov entered the depressurised base block docking module to shift the Konus device again. They took just 24 minutes to complete the task to relocate the device to the -Y port to ensure the docking of Spektr.

Late in the evening of 2 June the relocation of the Spektr module was completed. The module was moved from the -X port to the -Y port under the control of the cosmonauts and TsUP using one of the module's two manipulator arms. The operation took 2 hours to complete and left the relo-

cation of the Kristall module to the -X port as the final operation to be accomplished for the arrival of the Shuttle Atlantis.

Thagard Injury Scare

The Spektr module's complement of American and European experiments could now be removed for use by Dr. Thagard. Their delay by Russian customs was one of the many delays to postpone the launch of Spektr.

ITAR-TASS reported on 3 June that Thagard had experienced an injury scare that morning when the chest expanders he was using snapped and the spring caught him above an eye. The Russian agency called the injury "insignificant".

STS-71 Preview

Since late April, STS-71 has been at the Kennedy Space Center on Pad 39A. A report on launch preparations appears on p.249.

Correction

The duration of Valeri Polyakov's record-breaking space flight was 437 days 17 hours 58 minutes and 16 seconds which differs by 3 minutes from the widely reported value that was given in the June issue, p.191.

Russian Space Shuttle



The Buran space shuttle with its booster rocket Energiya during the countdown to the launching in November 1988. The gantry access arm on the Energiya rocket is believed to be the gantry arm that aborted the first launch attempt in late October 1988 when it moved too slowly out of the way in the final seconds before ignition and a computer aborted the launch.

A. MOKLESOVA/NOVOSTI

Projects, 1957-1994 - Part 3

BY PETER PESAVENTO
California, USA

The Buran programme was officially sanctioned in 1976. With lack of funds to carry on, it was finally abandoned in 1993 with massive wastage of money and resources. Part 3 of this article fills in the details.

Enter Buran

Unlike previous military projects before it, where Defence-Ministry-controlled design bureaus would build the spacecraft, the Buran is believed to be the first big military project let to the civilian-operated Ministry of Machine-Building. The Buran project came in two parts - the rocket launcher was to be built by NPO Energiya, under the direction of Valentin Glushko; the Buran shuttle was to be constructed at NPO Molniya, headed by Gleb Lozino-Lozinskiy, who had been transferred after the cancellation of MiG's project Spiral.

But problems, both technical and coordination-wise, abounded. Liquid oxygen-hydrogen rocket motors, to be used on the launcher, were giving the Russians great difficulties (gaseous hydrogen's liquefaction point is only a few degrees above absolute zero, and the super-cold element causes severe embrittlement of most materials and metal alloys; liquid hydrogen is also highly explosive when it comes into contact with other liquids or contaminants, meaning that extremely pristine conditions have to be present to fuel the rocket's propellant tanks). It was to be the first time a Soviet rocket would use such a propellant combination outside of the test stand.

Due to the size and complexity of the shuttle craft, no sub-scale analogue tests were planned (although ultimately, Russian engineers were forced to conduct such tests with 1/8th size models on six suborbital missions - and in the very year of Buran's first space flight). The first flight was therefore slated to be the first complete test under actual mission conditions. As a result, the shuttle design was continually in flux as the military changed its requirements - according to Golovanov, between 1979 and 1987 more than 32,000 changes were made in the design documentation for the shuttle's airframe.

While the Buran/Energiya project was experiencing severe developmental problems, it was under siege from another quarter - Vladimir Chalomei's OKB-52. According to information released in 1993, Valentin Glushko



The Buran space shuttle being prepared for its maiden flight in November 1988. The launch pad complex support tower in the centre right of the picture is the tower used for the N-1 rocket of the manned lunar landing programme.

A. MOKLESOVA/NOVOSTI

somehow managed to have the contract let for the Buran project without a standard prototype competition being held. In 1978 (or 1979), Chalomei challenged this by going directly to Premier Leonid Brezhnev and offering an alternative to the Buran project. But after a government commission looked into Chalomei's proposal, it was rejected - a seemingly foregone conclusion.

As a consequence, Chalomei made an unprecedented decision to build a flight-ready, crewable shuttle in secret. In one month, by by-passing the usual engineering procedures involving paperwork, the OKB-52 team designed and built a winged spacecraft, although Chalomei bureau engineers admit that the craft was built by borrowing liberally from the MP-1, M-12, and Almaz space station programmes materials already developed - such as control system and life-support equipment. The spacecraft would have been launched into orbit using an already proven rocket - the Proton. In anticipation of receiving an official government delegation with Defence Minister Dmitri Ustinov, the Chalomei craft was painted a bright military green with red stars on its wings and "СССР" in red letters on the fuselage - a kind of Soviet-style defence contractor advertising ploy. On the 31st day, Ustinov arrived to inspect the two-seat vehicle and came away impressed.

But Glushko's supporters inside the Soviet bureaucracy got wind of the audacious and illegal engineering performance of OKB-52 and moved to wrap up the project. Chalomei was called to the Politburo office of the Ministry of Machine-Building (it must be remembered that OKB-52 was actually a bureau under the jurisdiction of the Defence Ministry), who at the time was given control over roubles spent for space projects. Chalomei's engineering group was reprimanded

for irresponsibly spending 140,000 roubles (about \$210,000 US dollars) of the State's money, and were informed that their project was cancelled, because it had not been officially approved for development. The ejection seats that OKB-52 developed for its Buran challenger were actually transferred to the construction facilities where NPO Molniya engineers could inspect and further develop the seats for use in Buran.

Buran's Ascent and Decline

In mid-April 1985, a high-level meeting was held between the Buran's chief engineers and Politburo and Defence Ministry officials. The project was threatened with cancellation, due to all the development-time targets not being met. However, the Buran programme got a reprieve less than two weeks later, courtesy of the Americans.

In a published interview with Vyacheslav Filin, Deputy General Design Engineer at NPO Energiya, the US Space Shuttle Challenger mission launched on 28 April (that carried the Spacelab-3 microgravity mission) was tracked by Soviet radars. The US Space Shuttle executed what was interpreted as a bombing run over Moscow - the Shuttle had dived into the atmosphere over the city, and then went back up into space. "After that," Filin is quoted as saying, "the Politburo directed all effort to the development of an appropriate weapon. I can assure you that had it not been for the Buran system, there would have been no Reykjavik [a city in Iceland where arms reduction talks took place between Presidents Reagan and Gorbachev, and where Reagan first broached the idea of the sharing of Star Wars technology] - the Americans would have not talked to us." Many Western analysts believe that what Filin is broadly hinting at was that the Buran vehicle was part of the Soviet Union's Star Wars

system, and that the main purpose of the Buran was exactly what the Russians feared the American craft was for - nuclear bombing cities from orbit. This view is expressed by Alexander Velovich, a Russian aerospace analyst based in Moscow: "Yes, it is true that the Soviet government was worried about the US Space Shuttle attacking Moscow. But their response was to build the Buran [for the same purposes]."

However, despite the impetus, further decrees by the Soviet government for an actual space mission by specific dates for the Buran shuttle craft kept going by without being fulfilled. As time dragged on, the lack of coordination of the programme began to become more evident - instead of winding down the number of contractors working on the project, it grew instead - from 500 in the early 1980s to over 1500 by 1986, with the number increasing. The first Buran, with all of its systems operational (the life-support system was left out), was finally ready in mid-October 1988 - about eight years behind schedule.

Before the first Buran shuttle was to be launched into space, six research and testing models of the craft were built. Each had been given a "BTS-" number (an abbreviation for Buran Technologiskiy Samolet, or "Buran Technological Aircraft [Demonstrator]"). BTS-001 was an airframe made of metal but without any internal equipment and was used for aircraft transport tests. BTS-001 was ultimately used as part of the dynamic testing for the joint Energiya/Buran system at Baikonur. BTS-002 was the crewed subsonic analogue that was piloted on 25 air sorties.

The crewed subsonic Buran analogue BTS-002 is now at the MG Gromov Flight-Test Institute at the Zhukovskiy airfield outside of Moscow (presently mothballed). BTS-003 was a test-stand airframe that was fitted with the standard on-board systems, including computers and software. The engineers thought it would be possible with this test analogue to keep the whole process of developing the orbital craft on schedule. (BTS-003 is now at NPO Energiya.) BTS-004 was an engineering mock-up made of metal intended for working out the production and engineering work flow, as well as for refining aspects associated with the docking of the Shuttle with the Mir station and for fuelling and pre-launch checkout procedures. BTS-005 was a set of structural segments of the fuselage, wings and several airframe elements and was designed for vibration and acoustic tests. BTS-006 was also a set of structural segments, used for thermovacuum tests.

On 15 November 1988, the successful two-orbit, uncrewed maiden flight of the Buran took place. Its wheels touched the runway at the Baikonur

Cosmodrome 3 hours 25 minutes after lifting off. Post-flight inspection showed that only four of the 38,000 quartz-fibre, heat-shield tiles had fallen off. The landing of the Buran was shown live on national TV to the near-delirious announcements of Soviet commentators.

Despite the joy the Russians may have felt, and the commonplace predictions that a crewed Buran mission would take place within the next year or two, the high-water mark of the programme had already been reached. The writing was on the wall in late November 1991, when it was announced that the Soviet military had stopped funding the orbiter project. According to *Izvestia* science correspondent Sergei Leskov, "The idea of a reusable craft, is without a doubt, an advanced idea. But in our space programme, there are not yet any payloads of 25-30 tons, and Buran is like a heavy truck racing around the highways without a load."

On 30 June 1993, the Buran shuttle program was abandoned due to lack of funds made available by Boris Yeltsin's government. (There have been rumours that part of the reason why Yeltsin killed the project was because several of the coup plotters of the failed 1991 putsch supported the programme.) The cost of the cancellation was high: over 20 billion roubles (about \$30 billion US dollars) were thrown away, and 80% of the entire scientific and technical expertise that had been involved in some aspect of the programme now had to look for work elsewhere. Only one uncrewed flight had taken place, with two other Buran shuttles partially constructed. (It should be said here that the second flight-ready Buran vehicle was actually undergoing test-stand procedures on its on-board electrical systems and had a fully-functional life-support system.) Two further research and testing mock-ups were built for the second Buran, but remained unused by NPO Molniya who ordered them. Their numbers are BTS-011 (similar to BTS-003) and BTS-015 (fragments similar to BTS-006). Indeed, two complete Buran cabin mock-ups were also built, but have been haphazardly stored in a decrepit storage shed. In the aftermath, Lozino-Lozinskiy admitted that he had built the Burans against his own better judgment, under pressure "from above, and essentially in pursuit of the American shuttle."

A sad apotheosis for the Buran programme is perhaps the copy of the space shuttle sent to the Gorkiy Culture Park in Moscow (it is believed that this is either BTS-003 or 004). It is a former facilities stress and component-fitting test vehicle and is to be turned into the Russian equivalent of a park ride. By means of television monitors and computers, visitors sitting in the 48 seats of the cargo bay can experience the illusion of space

flight. The "space voyage" lasts about two hours, where the tourists will learn about how the space shuttle would have worked in space, assist the crew and stewardesses in fending off a meteor attack, and even meet friendly extraterrestrials during the mission. While aboard, the Buran passengers will eat real space food - prepared at the same institute that prepares the meals for real cosmonauts. The cost of admission is high, however - about 60,000 roubles (about US\$30). The site on which the forlorn spacecraft sits has been leased by the Buran's owners (a joint-stock company headed by Vostok-2 pilot Gherman Titov) for 20 years.

The Unlucky Cadre

The news item came over the wire at 3:30 pm from the Itar-Tass news agency on 19 July 1993: "Russian cosmonaut Igor Volk has been beaten up, stabbed in the chest and robbed on the Kashira highway in Moscow, the Interior Ministry reported." The news item further stated that the armed brigands had taken 80,000 roubles (in Russia's inflationary economy, it is the equivalent of about US\$65) and a gold chain. To add insult to injury, the robbers escaped in Volk's Mercedes, leaving him on the side of the road. He was brought to a hospital in Moscow for treatment of the wounds he sustained. The city's organized crime bureau was investigating the case. Later, the cosmonaut was discharged.

Volk, who was the head of the cadre that planned to fly aboard the Buran space shuttle, had experienced the latest misfortune to befall Russian cosmonaut team members that had trained to fly winged space vehicles. Between 1965 and 1989, 12 groups of pilots - totalling nearly 60 individuals - were selected to fly winged space orbiters, but never got the chance.

It all began in 1965 when the first three men were selected to train for the Mikoyan bureau's Spiral programme. By 1970, eight men had been in training. What was significant was the fact that the men were already flight-qualified cosmonauts, including one who had already flown in space, Vostok 2 pilot Gherman Titov, who became cadre leader. None of the cosmonauts would fly aboard a Spiral orbital vehicle - because the space flight phase of the project was wound down in 1972, although the cadre continued low-level work until their transfer to more promising space projects in 1976. But the Spiral orbiter cadre was destined to be the first and last time that active-duty cosmonauts would be assigned to a winged space project, rather than be selected expressly for a winged spacecraft programme.

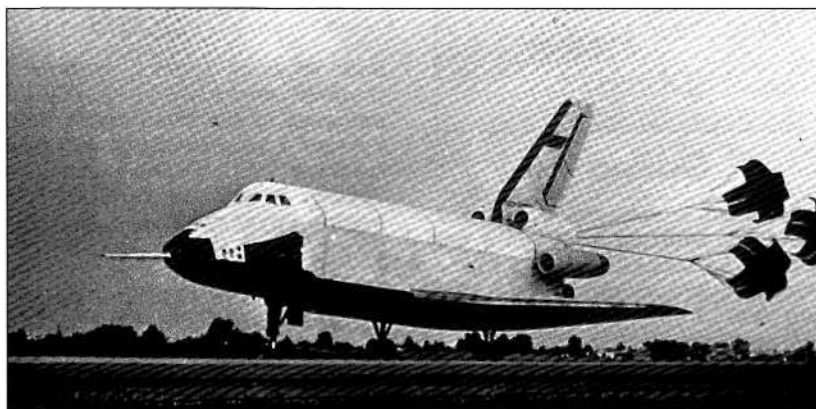
With the Buran space shuttle programme being officially sanctioned in 1976, the first group of nine cosmonauts were chosen to train to fly

Buran - even though no equipment or spacecraft was yet built. In 1977, another group was added, comprising an additional nine men, including Igor Volk. But tragedy first struck the programme in the same year - before the second group could begin medical examinations, two of them died in aircraft accidents in May and June 1977. In 1978, two more men were selected to replace the two deceased trainees.

In 1978, two further groups were selected, totalling ten men. One was a civilian group of engineers from NPO Energiya, while the others were candidates from the Ministry of Defence. (Many Western space analysts believe that the Defence Ministry selection was the first group chosen for training for the Hurricane shuttle killer programme.) In 1979, ten more candidates were assigned to the Buran programme, now totalling over 30 men.

In 1980, a further string of incidents caused setbacks to the shuttle cosmonaut cadre. In September and October 1980, two were killed in crashes of jet fighters, while a third was dismissed because of an unauthorized barrel roll in the sole Tupolev 154 flight trainer (an aircraft that had instrumentation similar to that on the flight deck of the Buran). In 1982, three more Buran trainees were selected, although this was offset by another shuttle cosmonaut candidate being killed in a helicopter transport crash in early February. In April 1983, one of the pilots from the original group selected in 1976 was dismissed from the cosmonaut team because of a contentious divorce. In July 1984, Igor Volk became the first Buran pilot to fly in space - but aboard the Soyuz T-12 spacecraft that visited the Salyut 7 orbital station. Volk spent 11 days in space.

Training to fly aboard the Buran space shuttle necessitated a large number of Earth-bound and airborne simulators to be built. Perhaps the most unusual training craft was the exact analogue of the Buran spacecraft built for atmospheric flight known as the BTS-002, but more commonly



The Buran space shuttle crewed analogue during a runway landing. It is an exact size counterpart to the actual space shuttle and was used to train shuttle cosmonaut candidates in the flight control characteristics of the shuttle in the atmosphere. It was powered by two jet engines, one on either side of the fuselage towards the rear. Twenty-five air sorties were flown with this aircraft prior to the Buran space shuttle's maiden voyage in November 1988. TIM LINDER

called just Buran. Unlike the actual space-capable shuttle that needs to be attached to the side of the Energiya super rocket to fly, the BTS-002 analogue had two jet engines attached to either side of the fuselage at the back of the aircraft.

The Buran analogue's first taxiing tests took place on 29 December 1984, and it was almost a year later, on 10 November 1985, that the first air sortie took place, with Volk and co-pilot Rimas Stankysvichus at the controls. In all, 25 flight tests of the jet-engined analogue took place up to mid-April 1988 with three pairs of shuttle cosmonauts gaining valuable training experience with the handling characteristics of the Soviet shuttle in the Earth's atmosphere.

In August and September 1985, two further groups of shuttle trainees were selected, although Western space analysts suspect that the three military pilots chosen by the Defence Ministry in August were additional personnel for the Hurricane project. But the next two years would see the Hurricane project become a shambles, personnel-wise.

In 1986, a Hurricane trainee was involved in a fatal accident (when an airborne weapons test went awry and mistakenly destroyed an aircraft) and

was dismissed from the team. In 1987, another Hurricane member was dismissed from the shuttle cadre because of his divorce, while three others were transferred to the Mir space station project in the Spring. In December 1987, another Buran pilot flew in space as a member of the Soyuz TM-4 crew to the Mir space station. Anatoliy Levchenko spent seven days in space before returning to Earth, becoming only the second shuttle candidate (and the last) to fly in space. It is believed by Western analysts that two other identified Hurricane team members were transferred to the Buran programme by the end of the year, following the shuttle killer's stand-down from active status.

In August 1988, in the space of 12 days, two Buran cosmonaut candidates died - Anatoliy Levchenko of a brain tumor in a Moscow hospital, and another in a jet fighter crash. In January 1989, four men were added to the burgeoning Buran cadre, to replace the August 1988 casualties. In September 1990, Buran analogue pilot Rimas Stankysvichus was killed in a fighter crash in Italy during an air show. His death would be the last of the ill-starred programme.

To many of the cosmonaut cadre, the demise of the Buran project before a single crewed mission could take place was preordained. It appears that there is a superstition (called "tradition" by the cosmonauts) that it is bad luck to name manned space projects before they actually fly. According to a published interview with Oleg Makarov, who was a veteran of several Soyuz/Salyut missions of the 1970s and early 1980s and who worked on the navigational system of Buran, "We have a tradition that the names are chosen only a few days before launching. Before, privately, everyone uses the factory serial number designators ... We have a very good tradition - to give the name only very late. With Buran, we had an exception, and it's a bad tradition." (Part 4 of this four-part series is to appear in a forthcoming issue.)

The Buran space shuttle stopped on the runway at the Baikonur cosmodrome following its successful maiden two-orbit voyage in November 1988. In the foreground, service trucks can be seen; in the background, the arid Kazakhstan steppe and other cosmodrome buildings are evident.

A. MOKLESOVA/NOVOSTI



Space Probe Diary

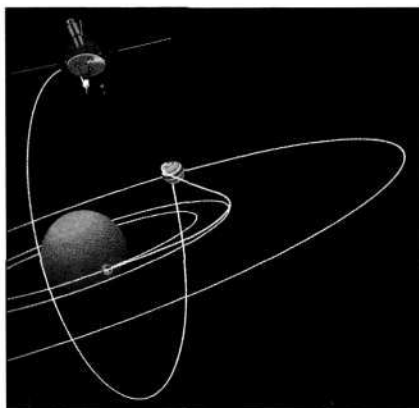
Galileo

The spacecraft is spinning at about 3 rpm and transmitting at 10 bits per second to the NASA/JPL Deep Space Network. Galileo is more than 790 million km from Earth and 144 million km from Jupiter.

Like the operating system of a personal computer, flight software translates commands from the ground and from a stored flight sequence into actions of the spacecraft. New software will be operating the spacecraft until March 1996. This critical period will see the checkout and deployment of the atmospheric probe, the approach to Jupiter, the Io flyby, capture and storage of probe data during the atmospheric descent and Jupiter orbiter insertion on 7-8 December 1995, as well as the subsequent transmission to Earth of probe data. In March 1996 an even more enhanced flight software will be installed to conduct orbital operations and data return.

The Galileo spacecraft is operating normally at the moment without a flight sequence, performing routine engineering activities on command from Earth. Round-trip communication time is 1 hour 28 minutes. A new flight sequence to control spacecraft activities from 13 March to 5 July, including the final probe checkout, was sent to Galileo in the second week of March.

Ulysses



On 12 March Ulysses made its closest approach to the Sun of about 192 million km. ESA

All Ulysses operations and science experiments continue to go well.

Flight controllers report that wobbling on board the craft, caused by illumination of the axial boom, has been stabilised, probably because the angle of the spacecraft to the Sun has shifted and the axial boom is now shaded from the Sun's heat. Flight controllers, however, are continuing to make adjustments to Ulysses' thermal control system to keep temperatures stable as the spacecraft approaches the Sun.

A three-way radio science experiment measured the electron content of the solar corona as Ulysses passed behind the Sun as seen from Earth.

Voyagers

Both Voyagers 1 and 2 continue to be tracked every day by the large antennas of the Deep Space Network. Voyager 1 receives about 120 hours of tracking time each week, while Voyager 2 receives about 90 hours a week. Voyager 2 is tracked less because it is sharing the DSN station in Canberra, Australia with the Galileo spacecraft. The Canberra station has the best "look angle" for both Voyager 2 and Galileo.

Both spacecraft are healthy and are continuing to make observations of their interplanetary environment and study the incoming interstellar wind. Cosmic ray detectors are providing energy spectra of interstellar cosmic rays in the outer heliosphere. The magnetometer sensors are still measuring the strength and direction of the solar magnetic field. The plasma detectors looking back at the Sun record the solar wind parameters. The low-energy charged particle experiment studies the energy spectra of particles coming from the Sun. The plasma wave instrument is studying incoming signals from the direction of the heliosphere.

It is now estimated that Voyager 1 will pass the Pioneer 10 spacecraft in January 1998 to become the most distant human-made object in the Solar System. Voyager 1 is currently 8.9 billion km from Earth and Voyager 2 is 6.9 billion km from Earth.

Flight controllers believe both spacecraft will continue to operate and send back valuable data until at least the year 2015. It is the loss of electrical power from their radioisotope thermoelectric generators (RTGs) that will eventually cause them to stop functioning. At launch, the three RTGs on each spacecraft had a power output of 475 watts. Today, that output is 348 watts for Voyager 1 and 351 watts for Voyager 2. The science ex-



The 1,800-pound Voyager has eleven scientific instruments, three radio-isotope thermoelectric generators, two radio receivers, X- and S-band transmitters, six control and data-management computers and twenty-four small hydrazine thrusters for stabilisation and course-change manoeuvres. JPL/NASA

periments need between 210 and 220 watts to operate.

The other vital consumable on board the spacecraft is the amount of hydrazine propellant which keeps the Voyagers stable and pointed toward Earth. Each spacecraft started out with 104 kg of propellant. Today, after 17 years on the job and multiple encounters and trajectory correction manoeuvres, Voyager 1 is down to 34.8 kg and Voyager 2 is at 37.3 kg. However, during the current quiet interstellar mission, each spacecraft uses only about six grams of fuel a week. Flight controllers stress that the Voyagers will run out of electrical power long before they start spinning out of control due to loss of their attitude-adjusting propellant.

New Transneptunian Object

A new object was discovered with the ESO 3.5 m New Technology Telescope in October 1994.

It was detected because of its extremely slow motion, only 3 arcsec/hour. Six accurate positions were measured and an approximate distance determined of 42 AU, which is far outside the orbit of Neptune; hence the classification as a "transneptunian" object. Its designation "1994 TG2" has been given by the Minor Planet Center of the International Astronomical Union. The observed magnitude is about 24. Its diameter is probably 100-200 km.

1994 TG2 is the 17th transneptunian object to be found during the past two years. Nine of these have distances between 31 and 36 AU, the other eight between 40 and 45 AU. None has so far been found in the gap in between and this may be an effect of Neptune's gravitational attraction. Colour measurements of some of the brightest have shown that they are unusually red.

Transneptunian objects represent an entirely new class of objects in the Solar System. It is not yet clear how they relate to other minor bodies like comets and minor planets, nor whether Pluto and its moon Charon, as well as the Neptunian moon Triton (which was observed from close

quarters by Voyager 2 in 1989), also belong to this class.

Venus Mission

On 7 March, Hughes Space and Communications Company became one of three teams selected to compete for a 1999 launch in NASA's new Discovery series of frequent, low-cost Solar System exploration missions, the Venus Multiprobe Mission (VMPM).

The mission's scientific objective is to gather data necessary to understand the peculiar behaviour of Venus' atmosphere, which rotates 60 times faster than the planet itself. Sixteen small probes, each about 38 cm in diameter and weighing about 23 kg, would be sent into the Venusian atmosphere from a spacecraft launched in mid-1999 aboard a Delta II rocket. Data on wind velocity, pressure and temperature from each of the probes would be collected back on Earth for post-flight analysis to complete the mission objectives. JPL would be responsible for science instrument definition, mission planning and project management.

The Venus Multiprobe Mission, along with mission proposals by two other teams, will undergo detailed study, leading to a decision to pick one for development and flight.

It Happened 26 Years Ago. . .

NOW is the Time to Take - STEP 2!

Do not close our window of opportunity to the future! The time has come to stop talking and take action. Mankind is putting his trust in the wrong form of space agency. Form an independent Corporation that buys services for the best price in order to achieve projects in space. Such a Corporation calls for massive backing from the public worldwide.

Since mankind took the "small step" on the Moon in July 1969 at Tranquility base, too much time has passed. Whoever would have believed that manned space exploration would stop there? The massive flow of enthusiasm of that time has now narrowed into a small stream of decreasing budget-minimised projects. The space station has had its budget slashed by US administrations so many times that it is scientifically questionable whether it should be built at all. Grand projects remain paper products and are then silently discarded into the trash-can.

Back in the 60s the political will was there to venture into space in order to prove one country's superiority over another. Since then the political will has eroded and faded away. What can be done about this? A lesson can be learnt from history - Columbus, an outcast of his kin, showed the way to new continents, Bell made the idea of speech over a wire into a reality - he too was not encouraged by those of his time until he proved the worth of his invention, awareness about our environment was awakened by noisy demonstrations by the youth of our time forcing these problems into the

limelight. The point is - established structures of authority do not (only by mistake) promote new ideas or actions that revolutionise the world order. Therefore it is not to be expected that the political system of the world will produce results like: Lunar Bases, Solar System Space Vehicles, Terraforming of Mars, Exploitation of Asteroids, Missions to the Outer Planets.

Man wants and is able to do these things, but he has put his trust in the wrong form of space agency. There is a brief window of opportunity which is not going to remain open forever. Right now we have a space transportation capacity with the US Space Shuttle and Atlas rocket systems, the French Ariane rocket, China's Long March rockets, the former Soviet Union's Proton-4 and Soyuz rockets and, soon to be completed, the H2 Rocket of Japan. This window is about to close. We must go now or stay behind forever! We do not need all these present micro-projects with micro-results to achieve our goals.

Projects that need to be put in hand are:

1. To return to the Moon and set up a permanent base there with industrial capacity;
2. To travel to Mars with the long-term goal of establishing a colony there;
3. To build the first Space Cruiser.

Funding from Governments with constant budget deficits will always be uncertain therefore the funds must come from elsewhere. So, how will this be done?

A well-understood platform is needed in order to gain acceptance and public support. Then set up a corporate firm and sell shares to the public. As this may not be possible from scratch due to the high costs involved, start with a Foundation and let the public become members of the Foundation which in turn supplies the Corporation with the money. This gives the Corporation the incentive to find the best buy on the open market for meeting the needs of its projects. When enough support and acceptance of the idea has been gained, shares can be sold to the general public and listed on the Stock Exchanges around the world. The Foundation can also

BY DANIEL N. MOSTROM

Linköping University
Sweden

About the Author



Daniel N. Mostrom

Daniel Mostrom is currently attending Linköping University in Sweden and is halfway into completing a Master's degree in Business with an international approach. He has spent a year as an exchange student in the USA and worked in both Germany and the USA. He has developed a particular interest in Finance, Computers, Corporate Organization Theory and has a lifelong interest in space-related matters. He comes from an engineering and entrepreneurial family in southern Sweden. The use of the new information technologies is fascinating to him and presents, in his view, great possibilities.

continue to function and to work as a think-tank.

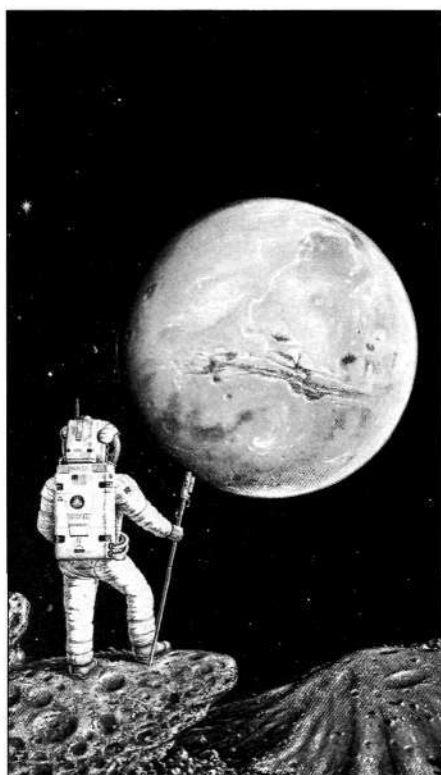
The name that I propose for the Foundation is "STEP 2" in order to cement the idea of a return into space. With regard to how it is organised, inspiration can be brought in from the business world.

I could find a 1000 difficulties with this proposal but it is my belief that it is the best opportunity that mankind will have and I am willing to take part in realising the goals set out here. If you want to go somewhere then you do not wait for a ride but you find your way and if necessary you construct the means needed to take you even if it happens to be a Space Rocket!

Any response to these ideas would be welcome as *Correspondence* to the *Spaceflight* Office. ■

'Next Step Mars'.

P.G. GOODWIN



Changing Weather on Neptune

Hubble Space Telescope views of the blue-green planet Neptune have provided three snapshots of changing weather conditions. The images were taken in 1994 on 10 October (left), 18 October (right) and 2 November (centre), when Neptune was 4.5 billion km from Earth.

Hubble is allowing Neptune's dynamic atmosphere to be studied with a level of detail not possible since the 1989 flyby of the Voyager 2 space probe. Building on Voyager's initial discoveries, Hubble is revealing that Neptune has a remarkably dynamic atmosphere that changes over just a few days.

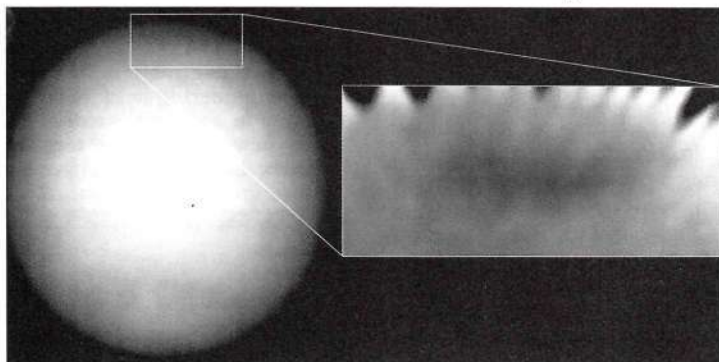
The temperature difference between Neptune's strong internal heat source and its frigid cloud tops (-260°F) might trigger instabilities in the atmosphere that drive these large-scale weather changes. In addition to hydrogen and helium, the main constituents, Neptune's atmosphere is composed of methane and hydrocarbons, like ethane and acetylene.



This picture has been reconstructed from a series of Wide Field Planetary Camera 2 images taken through different coloured filters at visible and near-infrared wavelengths. Absorption of red light by methane in Neptune's atmosphere contributes to the planet's distinctive aqua colour; the clouds themselves are also somewhat blue. The pink features are high-altitude methane ice crystal clouds. Though the clouds appear white in visible light, they are tinted pink here because they were imaged at near infrared wavelengths.

H. HAMMEL (Massachusetts Institute of Technology) and NASA

New Dark Spot on Neptune



This image was taken on 2 November 1994 with Hubble's Wide Field Planetary Camera 2, when Neptune was 4.5 billion km from Earth. Hubble can resolve features as small as 1,000 km across in Neptune's cloud tops.

It is not known how long lived this new feature might be, but Hubble's high resolution will allow the spot's evolution and other unexpected changes in Neptune's dynamic atmosphere to be followed.

H. HAMMEL (Massachusetts Institute of Technology) and NASA

NASA's Hubble Space Telescope has discovered a new great dark spot, located in the northern hemisphere of the planet Neptune. Because the planet's northern hemisphere is now tilted away from Earth, the new feature appears near the limb of the planet.

The spot is a near mirror-image to a similar southern hemisphere dark spot that was discovered in 1989 by the Voyager 2 probe.

Like its predecessor, the new spot has high altitude clouds along its edge, caused by gases that have been pushed to higher altitudes where they cool to form methane ice crystal clouds. The dark spot may be a zone of clear gas that is a window to a cloud deck lower in the atmosphere.

Astronomical Art

Io

An ordinary day on Io.
The Sun, coming out
from behind Jupiter,
illuminates an eruption
plume from one of the
smaller volcanic vents on
Io.

Joint painting by
RON MILLER and WILLIAM K. HARTMANN

For a report of astronomical observations from the Space Shuttle including observations of Io, see p.239.



Asteroid Fragment

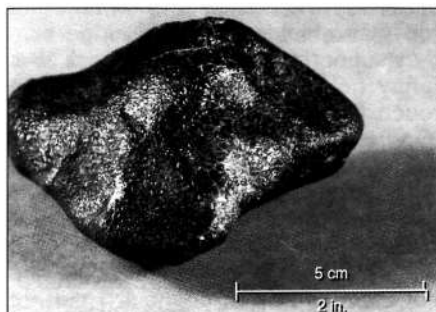
Most of the identified meteorites from Vesta are in the care of the Western Australian Museum. The 631 gm specimen in the photo below comes from the New England Meteoritical Services. It is a complete specimen measuring 9.6 cm x 8.1 cm x 8.7 cm showing the fusion crust, evidence of the last stage in its journey to Earth.

The meteorite is unique because it is made almost entirely of the mineral pyroxene, common in lava flows. The meteorite's mineral grain structure also indicates it was once molten, and its oxygen isotopes are unlike oxygen isotopes found for all other rocks of the Earth and Moon. The meteorite's chemical identity points to the asteroid Vesta because it has the same unique spectral signature of the mineral pyroxene.

The meteorite also has the same pyroxene signature as other small asteroids, recently discovered near Vesta, that are considered "chips" blasted off Vesta's surface. This debris extends all the way to an "escape hatch" region in the asteroid belt called the Kirkwood gap which is swept free of asteroids because Jupiter's gravitational pull removes material from the main belt and hurls it on to a new orbit that crosses the Earth's path.

The meteorite probably followed this route to Earth, being torn off Vesta's surface as part of a larger fragment. Subsequent collisions broke apart the parent fragment and threw pieces toward the Kirkwood gap and on to a collision course toward Earth. The fragment's journey ended in 1960 when it fell in Western Australia.

R. KEMPTON (New England Meteoritical Services)



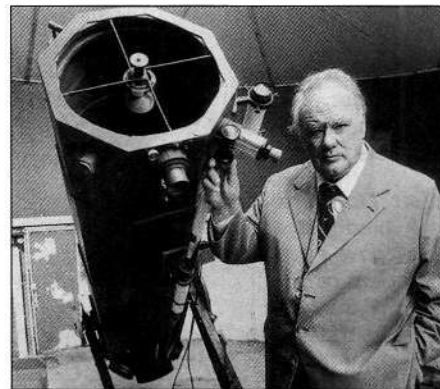
New Views of Vesta

BY PATRICK MOORE

BIS Fellow

There was a time, no so very long ago, when asteroids were heartily disliked by astronomers. They were in fact regarded as an unmitigated nuisance, and one irritated German went so far as to call them 'vermin of the skies' - incidentally, this is the title of the relevant chapter in Chesley Bonestall's classic book *The Conquest of Space*. Things are very different today. Asteroids are important - and not only because some of the smaller members of the swarm pass uncomfortably close to us (several have passed between the Earth and the Moon). In the far future we may well have asteroid beacons as navigational aids!

But until recently we knew very little about what asteroids looked like from close range. No Earth-based telescope will show any surface detail, and in most instruments an asteroid appears sensibly stellar. Remember only one, Ceres, is as much as 900 km in diameter, and only two others, Vesta and Pallas, exceed 500 km. Only Vesta is ever visible with the na-



ked eye.

Things have changed. Two small asteroids, Gaspra and Ida, have been imaged by the Galileo spacecraft during its somewhat tortuous path out to Jupiter. Both bodies proved to be darkish and cratered, and Ida was accompanied by a satellite, now called Dactyl. But Galileo went nowhere near the main members of the swarm, and we have had to wait for the Hubble Space Telescope to give us the first really good data.

Vesta has been the target. Between 28 November and 1 December 1994 Hubble took a series of pictures of it, covering more than a full rotation (a Vestan 'day' is 5.3 hours long) and showing features as small as 80 km across. Vesta has provided several surprises. The surface was already known to be unusual, and Hubble has now shown an exposed mantle with ancient lava-flows and impact basins. Evidently Vesta once had a molten interior; the old idea of asteroids being cold, rocky fragments left over during the formation of the main Solar System has been found to be very wide of the mark.

It has also been suggested that a meteorite found in 1960 at Millbillillie in Western Australia may have come from Vesta; it has the same unique pyroxene mineral signature, and its structure indicates that it was molten before cooling. Pyroxene is common in lava flows, and it has been inferred that the meteorite came from an ancient lava-flow on Vesta's surface. I admit to being somewhat sceptical - just as I am about the meteorites supposed to have come from the Moon and Mars - but at least the possibility is there.

I wonder if Vesta will ever be visited? For the record, it is 576 km in diameter, and it moves round the Sun at a mean distance of around 340 million km in a period of 3.6 years. The night sky would be interesting inasmuch as Vesta travels in the main asteroid zone, and has many smaller neighbours. No doubt it could be used as a beacon site - something which would have seemed out of the question when asteroids were still dismissed as cosmical vermin. ■

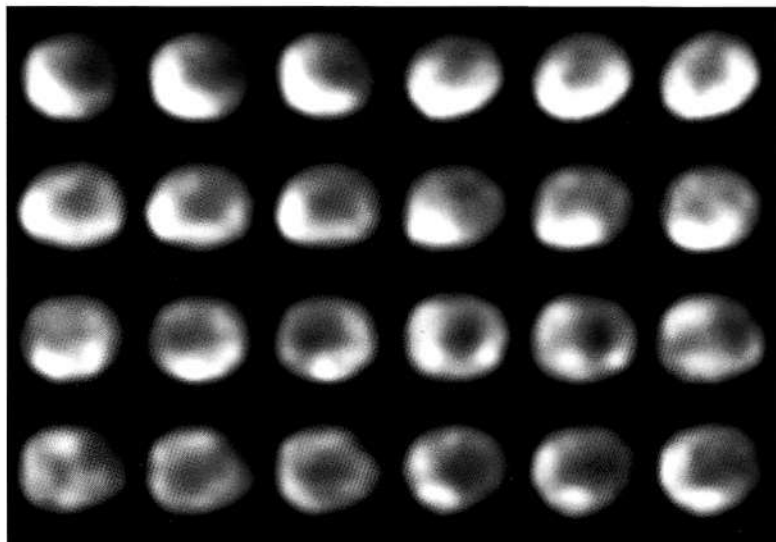
Vesta Images

The NASA Hubble Space Telescope has taken a series of 24 images showing the full 5.34 hour rotation of the asteroid Vesta.

Features are resolved that are small enough to allow astronomers to map Vesta's geologically diverse terrain. The surface is a complex record of Vesta's four billion-year history. Features include ancient lava flows and a gigantic impact basin that is so deep, it exposes the asteroid's subsurface.

This sequence was taken with Hubble's Wide Field Planetary Camera 2 between 28 November and 1 December 1994, when Vesta was at a distance of 250 million km from the Earth.

B. ZELLNER (Georgia Southern University) & NASA



Visit to

In fulfilment of a lifetime's ambition, *David Woods* visited the Visitor Center at the Kennedy Space Center last November. Although following in the tracks of many other visitors to KSC, he highlighted his visit by flying along the length of the Shuttle Landing Facility at 600 feet. He also kept a diary of his activities and has provided extracts from it for *Spaceflight*.

Visit Day One

A bleary eyed trip over the ocean. Just now I am not as excited by the prospect of visiting KSC as I would expect. I think the prospect of another 11½ hours on this plane, and the fact that my thigh muscles already feel cramped, is slightly dampening my anticipation. I will be happier when I get out of this seat and into the Florida sun.

Culture shock on arrival is not quite the right word for it. Driving on the turnpike is fine but the town roads quickly cause information overload as you try to filter the useful signs from the wall to wall advertising. Actually I did not do bad. The smile really got on to my tired features when, in no time, I was driving down the BeeLine past signs above the road saying 'Kennedy Space Center'. As I made my way to my digs near Merritt Island Airport where I intended to fit in some flying training, I caught a glimpse of the Vehicle Assembly Building (VAB), a ubiquitous sight in these parts. I felt, at last, that I really had arrived.

Visit Day Two

The brilliance of the sun startled me as I left the house and the soft warm humidity of the air was a pleasant alternative to the cool, air conditioned atmosphere of my digs. I drove north up highway 3 which became deserted as I left behind the heavy advertising of the town centre and entered the peace of the Cape Canaveral swamps. I eventually passed a gate house with a Mercury/Redstone rocket welcoming me to Kennedy Space Center, a restricted area. I was at first unsure if I ought to be driving here but then a notice invited me to tune into an AM station for tour info. That made me



The author and Mercury Sigma 7 which is exhibited in the Astronaut Hall of Fame.

feel better. The road, a four lane highway, just kept going, approaching the VAB until I did a left and saw a space shuttle (not a real one) showing that I had arrived at Spaceport USA. It was just after 10 in the morning and the next 7 hours would bring me to a long dreamed of place of pilgrimage. As one has come to expect, Americans had organised things well and I quickly bought tickets for the IMAX theatre and the red tour, both of which gave me times in the day when I would go to them. This is neat as it meant I did not have to queue and I could go and see something else for a while.

First off, the gallery of spaceflight. I was pleased to see the Apollo spacecraft from the Apollo/Soyuz Test Project, Gemini 9 and an unmanned

Mercury test craft. They were well presented and I could go right around them. Apart from very small areas, they were completely encased in shaped sheets of perspex. I understand why this is done but it does form a barrier to one's desire to touch these historic spacecraft. The Apollo spacecraft had its door open and that too was shielded but the hinge arm that supported the door was not. It is funny how people have this urge to touch the things that are of personal importance to them.

I was told that IMAX alone was worth going 3000 miles for. Now I know what they meant. I do not like abusing superlatives so I will say that the film brought me to tears at one point and smiles throughout. I did not expect much from IMAX. I got more than I even hoped. In *The Dream is Alive*, they cut to a shot of the Shuttle at the tower, filling your view and you hear the atmosphere of the Cape around you. You see a shower of sparks from the hydrogen pre-igniters that spray the bells of the SSMEs and you think "They're going to light this." It lights and as thrust is built up, the huge stack leans forward from the power. The SRBs light and off it goes. No music, no technical chatter or naff sound effects, no narrator abusing more superlatives; a launching shuttle needs no such ancillary froth. Is 'awesome' too hackneyed a word?

Next I climbed aboard a bus for the red tour clutching a bottle of drinking water to keep myself from being dehydrated in the heat. The tour was per-

The J2 engine of the Saturn V third stage with the Vehicle Assembly Building (VAB) in the background.



Florida

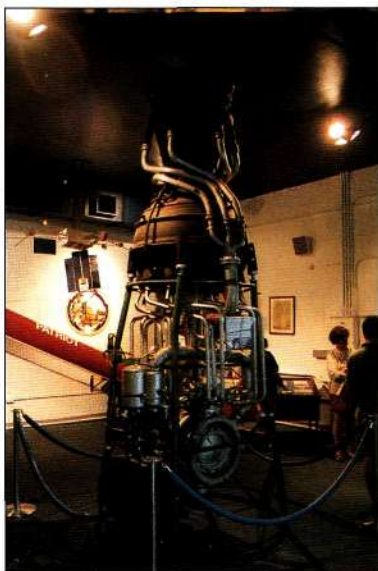
BY W. DAVID WOODS
Glasgow

fect for the tourist but I yearned to be left there for a while. I mean I loved it but I stood through a pale imitation of an Apollo countdown in one of the old buildings where the simulators used to be. Knowing the role the simulators played in the success of the Apollo venture, a display of the equipment in which people honed their skills would have been of greater interest. Having just watched the huge and detailed splendour of launches as seen by IMAX, this countdown simulation came across as a weak presentation. In an adjacent room they had a CSM and LM, both claimed as being flight worthy examples, not mock-ups. Then we were rushed to the VAB and shown a crawler/transporter up close, then on to the pads. They drove past 39B then on to a camera platform on a little hill-ock between A and B where we stopped for 5 minutes for photos. I could look over to 39A, where Apollo 11 had gone from. I was impressed but lacked time to think; to consider where I had got to. An event happened here that was a defining moment in my life and I am so busy running around trying to take photographs and getting Fred Bloggs to take one for me that I could not find time to let my spirit take its own path for a while and imagine. This hectic state of affairs was repeated at the VAB next to the Saturn V. I shall have to return.

Visit Day Three

I drove off up to KSC and got myself into the IMAX theatre again, this

A V-2 rocket engine in the museum at the Blockhouse, Complex 26, Cape Canaveral Air Station.



'Weary Old Lady' - the Saturn V on display at KSC with its paintwork streaked with too many days open to the sea air of Merritt Island.



Above: Mission Control Center for the Mercury and Gemini missions, Cape Canaveral Air Station.

Right: The LM display in the former Simulator Building.

The guide claimed that the LM, and the CSM next to it, were intended for flight.



time to watch *Destiny in Space*. I love IMAX. This is the greatest cinema format. Outstanding flights across the surface of Venus and Mars, generated by computer, footage of the deploy of the Hubble Space Telescope, and its subsequent repair, the view of Discovery from SPAS presenting the stunning exterior view of the spacecraft as if you yourself were floating alongside in graceful formation. These scenes are given an immediacy and, in the case of shots that depict motion, a terrific sense of movement by virtue of the detail and the enormous field of view they supply the brain.

Later, I searched out the Astronaut Hall of Fame just outside the Space Center. Another mock up of the shuttle was sat outside. Named 'Shuttle to Tomorrow' it contains rows of reclined, plastic seats laid out, aircraft

fashion, in its payload bay area. A pair of headphones each and a powerful speaker built into the seat gives the punter a 'multimedia experience' of a shuttle ride to tomorrow with Celestial Space Lines! Tackiness to the point of embarrassment. I can believe that kiddies (or Americans) will love this but it leaves a seasoned space buff like me cold.

On next to the Hall of Fame museum itself. Much of this typified the rather superficial and glitzy nature of the KSC Visitor Center but it was redeemed by having a notable collection of artifacts from various missions. Examples were hand written notes from a Mercury flight, the well worn computer keypad from Apollo 10's CSM and an arm rest taken from the Apollo 13 LM, Aquarius. There was also a Space Shuttle landing simulator which was a

VISITS

PC type flight sim where you used a joystick to land the shuttle from a few thousand feet up. I was chuffed when the machine congratulated me on an excellent landing and queried whether I had done this sort of thing before!

Visit Day Four

Tropical storm Gordon has conspired to force the expected landing of Atlantis to California so I have just watched it land on TV at Edwards Air Force Base in California.

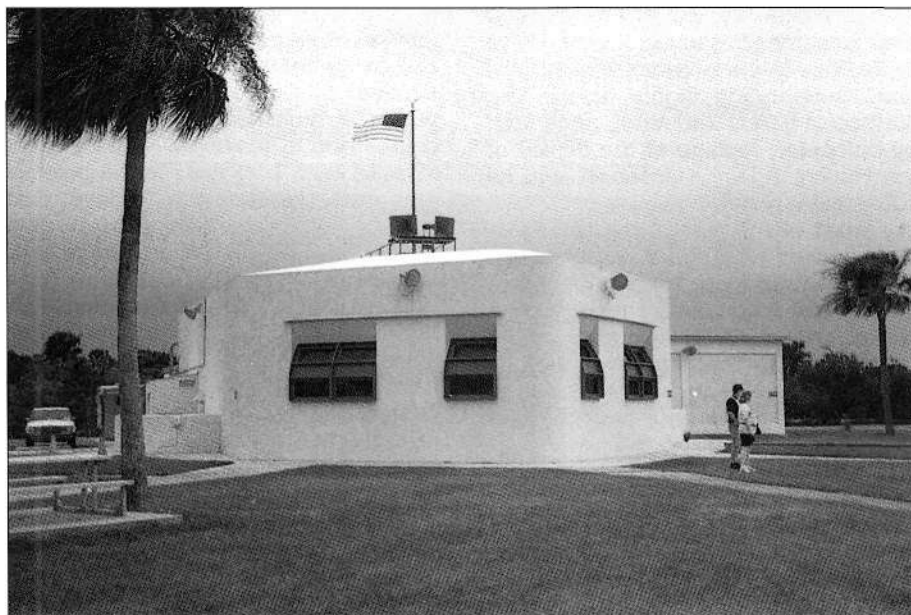
Unlike one's usual impression of Florida, the sky is heavy, overcast and as the evening draws in, there is, and has been, little light to take photographs. I took the Blue tour this afternoon to Cape Canaveral Air Station to visit the blockhouse, launchpads and control room from where America's first satellites and astronauts were launched; where historic figures like Werhner von Braun, Kurt Debus and other pioneer names pulled off fabulous events. I enjoyed this visit and wished it had not occurred under such oppressive skies. Still, I am having a ball. I keep catching myself walking around with my head as high as my spirit, my breathing as clear as my mind. Either this place is good for me or I am being pulled along by the wonder and enjoyment of being here.

More than on the red tour, NASA was showing us something close up that was real and historic. Less of the poor imitations. Mission Control for the Mercury flights is just as it was and the blockhouse is full of equipment of the age. This is to spaceflight what Kitty Hawk is to air flight. Time at the Air Force Space Museum for a little more thinking.

Visit Day Five

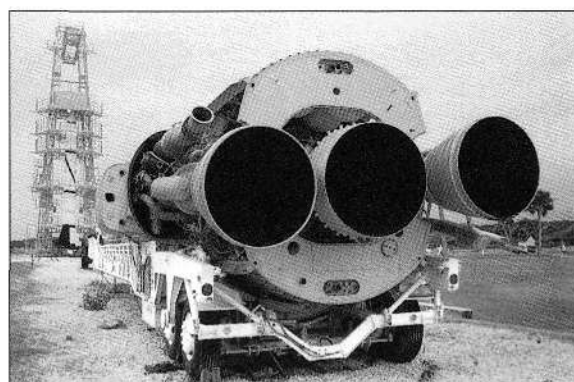
If I want weather like this I can go to Scotland for it! This is not just a shower. It has been pouring solidly at

The launch control Blockhouse, Complex 26, Cape Canaveral Air Station which was used for early unmanned and manned flights.



Above The Space Shuttle Landing Facility, KSC.

Right: The base of an Atlas rocket. In the distance Pad A, Complex 26, Air Force Space Museum, Cape Canaveral Air Station.



least since I got up an hour ago. I will get no flying today but on the airport's TV, I had a demonstration of the twenty or so TV channels available including an all day weather channel and NASA Select, a channel which gives 24 hour coverage of the space shuttle during a flight, and of the federal government at other times. Neat. If cable companies in the UK offer this service then I will be getting connected. Unlikely though.

Visit Day Eight

This is a bittersweet moment. I take off for home in less than 4 hours and in the last 2 hours the sun has come out with a vengeance. I am at KSC basking in the sunshine and writing. I got up at seven, was at the airport for eight and was flying at last with instructor Bob Conner in a Cessna 152 where the cloud was overcast at 1000 feet. Once we got up and had done some turns, Bob arranged on the radio for me to fly to the Space Center and along the Shuttle Landing Facility which I therefore got to fly along at 600 feet altitude for the entire 4.6km length of this huge runway and that was a real highlight for me. Soon after I landed, I was astonished when the cloud seem to vapourise in about a quarter of an hour and the day turned beautiful so I have just made a final visit to the Space Center to see the VAB, the rocket garden, Gemini 9 and the moonrock. I need another week. I could stay here forever. In a sense, this final visit to Kennedy is very important and it has left me content with my pilgrimage and its results though I feel that the needs of the space enthusiast could be better catered for by the companies who operate the visitor facilities at the Cape, and at a profit. Yet I am glad that I have visited the home of the Saturns and touched Apollo.

(All photos have been supplied by the author.)

KSC's Operations and Checkout Building

The Kennedy Space Center (KSC) in Florida is the technical heart of the Space Shuttle programme, where all elements needed for a specific manned space mission come together: orbiter, boosters, astronauts and, of course, the payload. This is a short background story, based on recent visits by the authors, of the Operations and Checkout (O&C) building at KSC where facilities are provided for handling large Shuttle payloads.

O&C Building

The Operations and Checkout building is a large five-storey office building (56,000m²) that surprisingly is not located near the more well-known Vehicle Assembly Building, but in another area at KSC, namely right between KSC Headquarters and the new Space Station building. About 800 people, most of them from contractors work in the O&C building. On its second and third floors are NASA's medical and astronaut quarters, where the Shuttle crews stay during rehearsals and the periods right before launch and after landing. The famous "side door" is the "Walk-Out" position where all fully-suited space crews give their last farewell to reporters and step into the van that takes them to the launch pad.

The ground floor of the O&C building is almost entirely set up as a very large "white room" where most fixed Shuttle payloads are processed before and after their operations in space. Only in the separate Vertical Processing Facility are large Shuttle payloads also prepared for launch, but such payloads are intended to stay in space (satellites, experimental platforms, planetary probes).

O&C's white room is used basically for large Spacelab payloads and consists of a high-bay area (53 m long x 32 m high x 26 m wide) and a low bay area (145 m long x 21 m high x 26 m wide). The temperature inside is controlled at 24°C (±2°C) and the humidity level is kept at 60%.

USML-2 equipment during systems testing.
LUC VAN DEN ABELEN



The "white-room" low-bay area in the O&C building in February 1995.

E.R. VAN BEEST

Processing Spacelab Missions

The O&C's white room has two large Spacelab integration workstands next to several other smaller workstands; it offers four main areas where specific large payloads can be processed simultaneously. On our first short visit in August 1994, the four main areas were taken up by IML 2 (after the STS-65 mission), Atlas-3 (for the STS-66 mission), Astro 2 (for the STS-67 mission) and Spacelab-Mir (for the STS-71 mission). On our longer stay in February 1995, we again saw Spacelab-Mir (still for STS-71) and Atlas-3 (now back from the STS-66 mission), this time with USML-2 (for the STS-73 mission) and SRL-2 (back from the STS-68 mission).

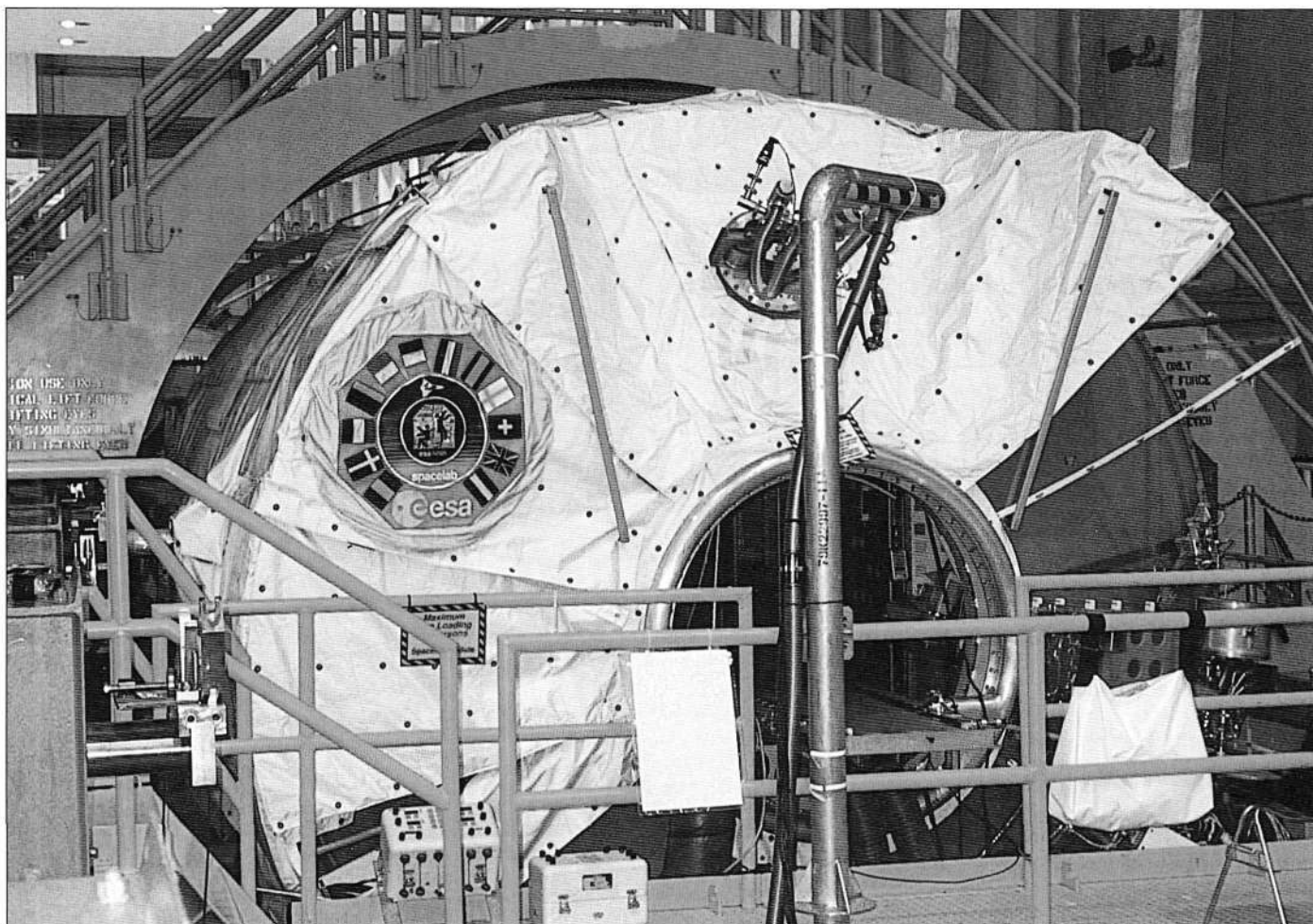
In other places in the white room are smaller payloads like the TSS (for STS-75) and the Shuttle-Spacelab transfer tunnels, while from the old days the (Apollo) High Altitude Chamber is still in use as a Spacelab Vertical Access Simulator.

Clearly almost all these payloads are for specific Spacelab missions or are mounted on Spacelab-developed pallets, and since ESA delivered both Spacelab cylinders and all pallet carriers, a lot of European-built hardware is involved! Looking at the Shuttle manifest it shows that nowadays nearly all large Shuttle payloads go and come from this floor. Before these payloads arrive at the O&C building for integration, they are technically

The famous "side door" of the O&C building that regularly features in crew departure photos is obscured by the NASA transport vehicle. Here the general departure scene is depicted showing the exterior of the building and the gathering of waiting photographers and onlookers. Shown here is the STS-55 Spacelab D-2 crew.

ANNE VAN DEN BERG





Spacelab-Mir after being fitted out and awaiting installation in the payload bay of Atlantis. The ESA logo with the flags of the ESA member states is indicative of the involvement of European-built hardware.

LUC VAN DEN ABELEN

designed and developed at NASA's Marshall Space Flight Center in Huntsville; NASA's major contractor for large payloads there is Teledyne Brown Engineering, which has become an important contributor to the Shuttle programme.

Teledyne Brown Engineering

Together with their major activities at Huntsville and their Liaison Office at the O&C building, Teledyne Brown Engineering prepares nearly all horizontally integrated Space Shuttle payloads, basically for Spacelab missions like IML, USML, USMP, Astro, Atlas etc. Teledyne also builds some mis-

sion peculiar carriers, such as payload bay support structures.

At NASA Marshall (Huntsville), some 400 engineers work for Teledyne, where the design of the experiment, rack and structure hardware takes place. This work is carried out in co-operation with the principal investigators and experiment engineers. Before installation in the Spacelab cylinder, the entire payload, including the scientific instruments, computers, power, cooling and communication equipment, is tested in the O&C building as an integrated system. The interface with the Shuttle is tested by using an orbiter aft flight deck simulator. When ready for flight, the payload is transferred to the OPF for integration in the orbiter cargo bay.

Some two to three years of Teledyne effort precedes any KSC activity on payload hardware. Teledyne also trains the astronauts for the operation of the payloads in orbit and monitors the equipment during the mission. Teledyne is therefore involved in payload support from assignment to completion of the flight.

Teledyne also supports the integration of ESA developed Shuttle payloads like Biorack and Glovebox, acting as field liaison for ESTEC's Microgravity Department. In the near future Biorack is even to be flown on Spacehab for NASA, while a Glovebox flies to Mir on board Priroda. Teledyne

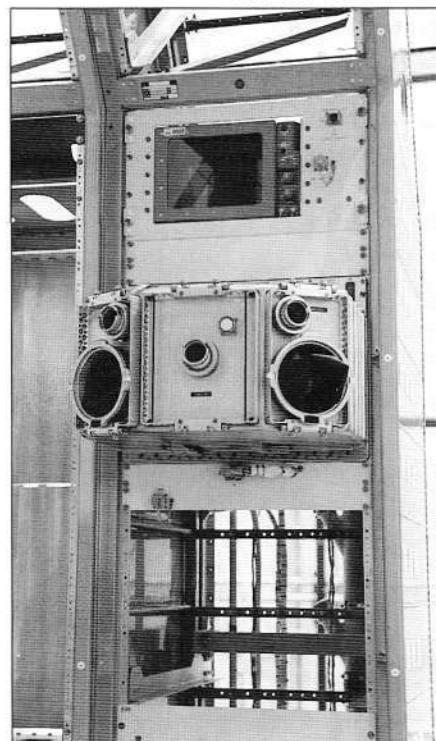
is subcontractor for their preparation on these missions as well.

Acknowledgements

Ms K. Grinter and Mr J. Bartoszek from NASA/KSC, Mr C. Blass and Mr W. Lorson from Teledyne and Mr E. Hengeveld.

Glovebox, produced in The Netherlands by Bradford, in preparation for USML-2.

LUC VAN DEN ABELEN



'Commercial Launchers' Competition Winners

Winners to whom book prizes will shortly be dispatched are:

First Prize:

A. Chandran India

Runner Up Prize:

B. De Wilde Belgium

Consolation Prizes:

O. De Peyer UK
C. Gamble Switzerland
A. Radonic Croatia

The correct answers are:

1. Atlas 2AS; 2. H-2; 3. Zenit 3; 4. CZ (i.e. Long March) 2E; 5. GSVL (also accepted is GLSV due to misprint); 6. Proton; 7. Titan 3; 8. Titan 4.

Astronomy from the Shuttle

The dramatic liftoff of Endeavour on 2 March 1995 saw the start of a nearly 17-day mission of concentrated and wide-ranging astronomical research. Details of the three main payload bay instruments (HUT, UIT and WUPPE) and preparations for launch have already appeared (*Spaceflight*, February 1995, p.64 and May 1995, p.162). Roelof L. Schuiling now provides an account of the in-orbit activities during this very successful mission.

Introduction

The ASTRO-2 telescopes and instruments were mounted upon a Spacelab program Instrument Pointing System (IPS) which was in turn mounted upon a Spacelab program pallet. At the forward end of the pallet was mounted a pressurised container, called the Igloo, which housed the payload's computers and memory unit.

The seven-member crew of STS-67 were divided into two shifts for round-the-clock mission operations. The Blue team of Mission Specialists Tammy Jernigan and Wendy Lawrence, together with Payload Specialist Sam Durrance had the first shift as the Red team of Mission Commander Steve Oswald, Pilot Bill Gregory, Mission Specialist John Grunsfeld, and Payload Specialist Ron Parise began their first orbital sleep period.

Flight Day One

Telescope activation continued throughout the Blue team's shift and took longer than planned as a steering jet leak twice caused the instruments' protective doors to be closed. The failed jet was not however a threat to the mission as redundant systems were available.

Flight Day Two

Calibration of the telescopes was

Astronaut John M. Grunsfeld, mission specialist, uses a handheld Hasselblad camera to record the ASTRO-2 payload as shown in the photo above. NASA



BY ROELOF L. SCHUILING
at the Kennedy Space Center

necessary before actual observations could begin. Assessments of the IPS stability and accuracy showed the system to be operating well. The first science observation for ASTRO-2 was a supernova segment known as the Cygnus Loop.

The UIT made its first observations which included images of globular clusters. These are massive spherical concentrations of stars that are the oldest class of objects in the Milky Way. The clusters appear to be 16 to 19 billion years old, despite recent Hubble Telescope indications that the universe is only about 10 billion years old. The UIT ASTRO-1 observations during STS-35 revealed a previously unknown class of stars, visible only in ultraviolet, which may have skipped a stage in stellar evolution as it is understood. Astronomers hoped follow-up investigations with ASTRO-2 would provide a better understanding of the stellar processes involved.

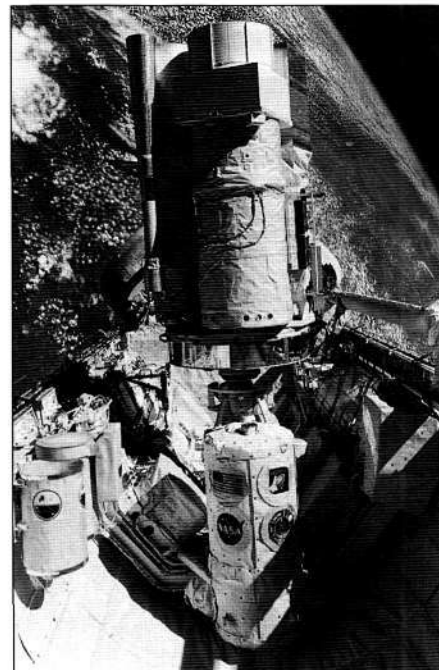
ENDEAVOUR

Orbital Flight:

2 - 18 March 1995

The HUT observed a celestial "odd couple", two stars with radically different temperatures orbiting around one another. The system, EG Andromedae is made up of an exceptionally hot blue star and a giant orange-coloured star. Such a system is termed a symbiotic binary system. Astronomers had not known just how hot the smaller star was until its strong ultraviolet emission was picked up during one of the Voyager planetary probe missions. The HUT team checked out the sensitivity of their spectrometer by observing a white dwarf star called HZ 43 which had been observed during ASTRO-1. The conditions inside white dwarf stars are very well understood and can, therefore, be used to calculate precisely how much ultraviolet light they emit, which makes them very useful for HUT calibrations.

The WUPPE team made several planned observations of the supergiant star P Cygni which were designed to provide information on how this type of star ejects matter into space either



The 70 mm cargo bay scene, backdropped against a desert area of Namibia, typifies the view that daily greeted the ASTRO-2 crew members during their almost 17 days aboard the Space Shuttle Endeavour. Positioned on the Spacelab pallet amidst other hardware, the ASTRO-2 payload is in its operational mode. Visible here are the Instrument Pointing System (IPS), Hopkins Ultraviolet Telescope (HUT), Star Tracker (ST), Ultraviolet Imaging Telescope (UIT), Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE) and Integrated Radiation System (IRS). At this angle, the Optical Sensor Package (OPS) is not seen. The Igloo, which supports the package of experiments, is in the centre foreground. Two Get Away Special (GAS) canisters are in the lower left foreground. The Extended Duration Orbiter (EDO) pallet, located aft of the cargo bay, is obscured by the ASTRO-2 payload. Endeavour was 190 nautical miles above the Earth. NASA

as plume-like ejections or uniform shell-like ejections. This star has recently entered an active phase after being relatively inactive during the past 100 years. Since it can vary from day to day, observations were also made later in STS-67 for comparison.

Flight Day Three

HUT and WUPPE combined together to study the symbiotic binary system AX Persei. Little is presently known about how these pairs of stars interact although it is believed that gas from the large cooler star falls on to the smaller but more massive companion.

HUT and WUPPE were also used to make measurements of a Wolf-Rayet star called EZ Canis Majoris. Wolf-Rayet stars are thought to represent one of the final stages of evolution in massive stars that are between 100,000 and 1,000,000 times as bright as the Sun. Such stars produce powerful stellar winds or emissions of ionised gases, that quicken the star's ageing process. The composition of these stellar winds is important as their components play a significant part in forming the basic chemistry of life in the universe.

HUT was active in planetary studies during the day. The instrument studied



Astronaut Tamara E. Jernigan, payload commander, looks at a display of data from the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE) on the flight deck of the Earth-orbiting Space Shuttle Endeavour. NASA

Jupiter which is thought to have a reservoir of heat energy left over from its creation since the planet radiates heat energy at twice the rate that it receives it from the Sun. HUT and the other two ASTRO-2 telescopes also made observations of a volcanic eruption on Jupiter's Moon Io.

WUPPE made the first mission observations of the illuminating star in the reflection nebula NGC 7023 in order to study how stars are created from nebulous clouds of gas and dust. A young star at the nebula's core was formed from the cloud's material. WUPPE made the first ultraviolet observations of the spectrum of the recently-discovered Nova Aquillae. An outburst in this system was first noted by an amateur astronomer in Japan.

The UIT telescope made observations of the globular cluster NGC 6752 and the spiral galaxies M101 and M83. The M83 observations will be used in an atlas of face-on spiral galaxies which is in preparation at the University of Chicago. Scientists will use the ultraviolet images from nearby galaxies to help classify shapes of distant galaxies photographed in visible light by the Hubble Telescope. The light actually left the distant galaxies as ultraviolet, however it was stretched into the visible spectrum by the expansion of the universe. Observations of globular clusters in ultraviolet allow astronomers to pick out the hotter objects, which are burning helium, from the clutter of cooler stars which are mostly burning hydrogen.

Flight Day Four

HUT made observations of a mysterious star in Cassiopeia known as KPD0005. The star belongs to a class of planetary nebulae with bright centres that are so hot that their surface elements are completely ionised and consequently their chemical composition is difficult to analyse. HUT also made studies of Type II Seyfert galax-

ies. Galaxy NGC 1068 was observed in a study to determine if the core is ionised by powerful shock waves moving at hundreds of miles per second.

The WUPPE team also observed NGC 1068 and made some very difficult observations of the galaxy's core by using the electron cloud above the galaxy as a polarisation mirror and observing the diffuse light reflected from the cloud to take measurements of the otherwise obscure core of the galaxy.

HUT and WUPPE both examined the two Seyfert galaxies Markarian 279 and Fairall 9 in a study of galaxies with extremely bright compact cores containing gas moving at thousands of miles per second. Astronomers have theorised that supermassive black holes may be the only sources capable of generating the immense power given off by these galaxies.

WUPPE viewed the interactive binary star systems V356 Sagittari and Vela X-1, an X-ray binary, in which a neutron star or pulsar gradually strips

material off its companion star. Much of the material may settle in an oval disc shape and WUPPE measurements were made to determine the size and shape of the disc.

Flight Day Five

HUT scientists continued observations of the quasar 1700+64 in studies aimed at discovering intergalactic helium. "Cataclysmic variables" which consist of a white dwarf star near the end of its life cycle and a normal star similar to our Sun were also targeted. Occasionally there is an outburst or sudden increase in energy emissions and interchange of matter, called an accretion.

Other HUT observations included:

- (1) the elliptical galaxy M105 in Leo in a study of stars that put out an unexpected amount of ultraviolet light;
- (2) images of the Cygnus Loop nova remnant from a stellar explosion 20,000 years ago; and
- (3) studies of individual stars ranging from the most massive to compact white dwarfs.

The UIT took images for "Selected Area 57" which is an intensively mapped area of the sky which astronomers from all over the world are studying.

The WUPPE team reported what may be confirmation of a surprise finding from ASTRO-1. The team saw evidence of two types of polarised dust in an interstellar cloud. The two types of the dust were like sand and like soot. Although polarisation had been noted in the sand-like dust ASTRO-2 confirmed ASTRO-1's finding of polarisation in the soot-like dust as well.

WUPPE investigators made the first observations of Nova Aquillae, a binary star system which consists of a white dwarf and a normal star. The system became a bright nova about a week previously due to hot gas from the normal star being pulled on to the

ASTRO-2 payload specialist Samuel T. Durrance talks to payload support personnel at the Marshall Space Flight Center (MSFC) from the flight deck of the Space Shuttle Endeavour. Durrance is a Principal Research Scientist in the Department of Physics and Astronomy at Johns Hopkins University. NASA



white dwarf star resulting in thermonuclear explosions which increased its brightness a thousand times.

Flight Day Six

Crew members began their rounds of off-duty rest shifts which are a feature of longer flights. Payload Commander Jernigan had the morning off in the first of the off-duty rest shifts. Other crew members had time off later.

ASTRO-2 observations included several spiral, an elliptical and a starburst galaxy as well as individual star studies. All three telescopes joined in studies of two active galaxies, NGC 4151 and NGC1068, thought to have massive black holes at their cores. NGC 4151 was five times as bright as it was during ASTRO-1 and showed a 10 per cent increase in brightness over the early mission observations.

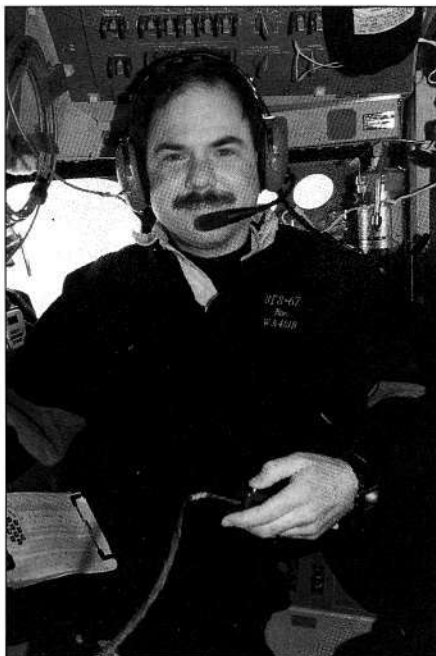
Flight Day Seven

All three ASTRO-2 telescopes took part in studies of galaxies NGC 2841 and NGC 2403; while HUT and UIT observed NGC 205 and a starburst galaxy. The three telescopes studied Wolf-Rayet stars as well as two massive blue stars emitting large amounts of ultraviolet radiation.

The HUT continued studies of cataclysmic variables with observations of dwarf novas U Geminorum and SS Cygni. U Geminorum was at a quieter phase during ASTRO-2 than it had been during ASTRO-1. Members of the American Association of Variable Star Observers and amateur astronomers over the world were maintaining a 24

ASTRO-2 payload specialist Ronald A. Parise reminisces his in-space amateur radio experiences of five years ago on the ASTRO-1 mission. Using the Shuttle Amateur Radio Experiment (SAREX), Parise talks to students on Earth from the flight deck. On flight day five, crew members used the SAREX equipment to talk with students in Australia, South Africa and India.

NASA



Astronaut Wendy B. Lawrence, flight engineer and mission specialist, scribbles notes on the margin of a checklist while monitoring an experiment on the Space Shuttle Endeavour's middeck. The experiment is the Protein Crystal Growth (PCG), which takes up locker space near the Commercial Materials Dispersion Apparatus Instruments Technology Associates Experiments (CMIX). In addition to supporting ASTRO-2 operations, Endeavour's crew also worked with the CMIX experiments which use the microgravity environment to aid in the development of drugs and drug delivery systems on Earth.

NASA

hour a day monitor watch of variable stars and furnished regular E-mail reports to the ASTRO-2 experiment teams so that objects of interest could be added to the mission's observation schedule.

Flight Day Eight

As the mission approached its halfway point controllers reported that consumables usage was proceeding as planned and saw no threat to Endeavour completing its then-planned 15½ day flight.

Thousand of questions for the mission had been pouring into the ASTRO-2 World Wide Web Home Page which was available to personal computer users. Mission Specialists Jernigan and Lawrence took time out to respond to questions from the Web users.

A large portion of the day's observations included studies of the planet Jupiter and its moon Io. A volcanic eruption, just before the STS-67 launch, ejected material on to Io's surface and into its atmosphere and as Io orbits Jupiter some of the material is left behind along Io's orbit. ASTRO-2 teamed up with the Hubble Space Telescope to study Jupiter's northern lights. Hubble's Wide Field/Planetary camera and the STS-67's HUT studied the auroral region of the planet. Payload Specialist Sam Durrance's astronomical speciality is the planet Jupiter and he used the HUT to study the northern area of the planet.

Flight Day Nine

Endeavour's crew again took time out from their busy schedule to answer a number of questions which had been left for them via the World Wide Web. Hundreds of thousands of internet user access sessions were

logged.

Payload Specialist Parise used HUT to make observations of the cataclysmic variable AM Herculis which is a system made up of a white dwarf star with a strong magnetic field and a low-mass companion star. Matter is transferred from the companion to the white dwarf and assembles around the magnetic poles. Transfer in the presence of a magnetic field differs from the normal transfer of matter between binary stars and so HUT also made observations of EM Cygni, a dwarf nova with no magnetic field.

Observations of Jupiter's moon Io continued as scientists studied the changes in sulphur and oxygen ions in Io's atmosphere as a result of the recent volcanic eruption.

UIT was active in mapping the northern portion of the Andromeda galaxy, M31, in a study of groups of hot young stars called OB associations to learn more about the formation of stars within the galaxy. The southern portion of the galaxy was mapped on ASTRO-1's mission.

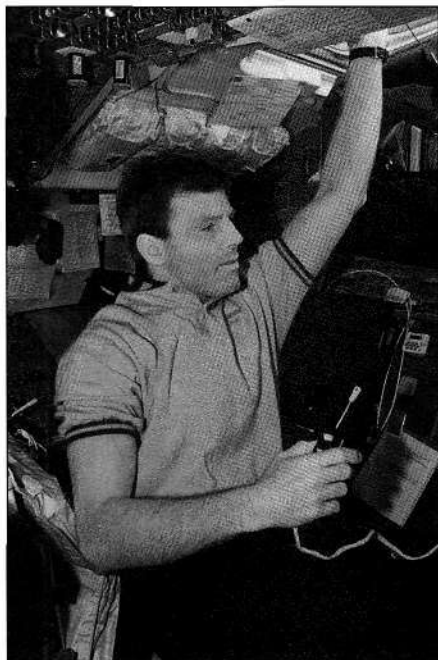
Other UIT galactic studies included the galaxy NGC 4631, a large spiral galaxy, which is pulling matter from a nearby elliptical galaxy called NGC 4656. UIT studies will provide data on how gas is heated and then cooled and dropped into the disk.

Flight Day Ten

Endeavour's crew again answered questions from the world's internet users as the mission continued to accumulate astronomical observations.

The WUPPE instrument made observations of the Nova Centauri 1995 which occurred only two weeks prior to STS-67's launch.

HUT observed two Seyfert-1 galaxies, which are galaxies with bright



Astronaut Stephen S. Oswald, mission commander, pauses while communicating with ground controllers from the flight deck. NASA

compact nuclei radiating in wavelengths from infrared to X-ray, simultaneously with X-ray observations from the Japanese Advanced Satellite for Cosmology and Astrophysics.

UIT's observations included open stellar clusters within our galaxy and the spiral galaxy M101. M101 is a perfect example of a galaxy with arms that are wide and not tightly wound. It was the highest priority spiral galaxy for the UIT instrument.

Flight Day Eleven

Astronomical observations had a new and exciting target as the crew made the first detailed observations of the Moon in the ultraviolet spectrum. No previous Shuttle, Apollo or Clementine mission and no operating or planned spacecraft has been or will be capable of imaging the whole Moon at far ultraviolet wavelengths. The WUPPE instrument also made observations of the Moon and ASTRO-2's three telescopes all made observations of the planet Mars.

Flight Day Twelve

Astronomers using WUPPE to study Mars were surprised to find that the polarisation of ultraviolet radiation from the planet is due to the planet's soil composition rather than the atmosphere. A similarity between Martian and Moon ultraviolet polarisation was reported. HUT observed Venus for traces of argon, neon and helium which are important indicators concerning the Solar System's formation. HUT studies included galaxies, pulsating white dwarf stars, a young star just emerging from its cocoon of gas and dust and planetary nebulae.

Flight Day Thirteen

This was an historic day as a

record 13 humans were flying in space at one time. Eight were American as Astronaut Norm Thagard had been launched with two companions, Vladimir Dezhurov and Gennadiy Strekalov, aboard the Russian Mir-18 mission which was rendezvousing with the Mir space station and its crew of the three cosmonauts Helena Kondakova, Alexander Viktorenko and Valery Polyakov.

During the day, mission managers decided not to extend STS-67 beyond the planned landing at the Kennedy Space Center on 17 March. However, weather conditions later in the flight precluded this plan.

Flight Day Fourteen

The crew of Endeavour interrupted their astronomical observations during 15 March for the planned test of the orbiter's flight control system in preparation for the end of the STS-67 mission which was then scheduled for 17 March. Mission Commander Steve Oswald, Pilot Bill Gregory and Mission Specialist Wendy Lawrence fired up one of Endeavour's three Auxiliary Power Units to provide power for the flight control system and its aerosurfaces.

All three telescopes were in operation and made studies of the M87 elliptical galaxy in the constellation Virgo at the centre of which a 1994 observation by the Hubble Space Telescope had shown indications of a supermassive black hole.

Overnight the ASTRO-2 instruments again studied the ultraviolet emissions from the planet Jupiter and its moons Io and Callisto.

Flight Day Fifteen

At 2:45 am (KSC-time) on the morning of 16 March the Soyuz spacecraft docked with the Mir space station and astronaut Norm Thagard and his two cosmonaut crewmates entered Mir at about 4:30 am. Later in the day Endeavour Mission Commander Steve Oswald spoke with Thagard in a radio hookup between the two spacecraft.

With the planned landing of STS-67 set for the following day, the crew were busy with their last astronomical observations.

Flight Day Sixteen

Shortly after midnight, the ASTRO-2 science operations concluded with all three telescopes taking observations of the full Moon.

After completing the astronomical studies and readying their spacecraft for its return to Earth, the STS-67 crew joined mission controllers in watching the weather at the Kennedy Space Center. After waiting until all three of the possible landing opportunities were ruled out, the decision was made to postpone the landing until the following day as high winds, rain and clouds were sweeping the Florida peninsula. Almost immediately after the

postponement, the Blue team astronauts began an eight-hour sleep period but were awakened shortly after midnight to monitor the Endeavour's systems for one more night as the Red team began their last sleep period.

Flight Day Seventeen

Plans called for a possible landing at the Kennedy Space Center at 3:18 pm, however the weather forecast at the Florida site did not appear favourable. As the time for landing approached, the weather in Florida did not improve and when the first Florida landing opportunity had passed mission controllers elected to land at the Edwards Air Force Base in California on the first landing opportunity.

Endeavour performed its retro engine burn and after reentry landed at Edwards Air Force Base on Runway 22. Main landing gear touchdown came at 16 days 15 hours 8 minutes and 47 seconds after launch at 4:47:47 pm (KSC-time). Nose gear touchdown was at 16 days 15 hours 9 minutes and 1 second after launch, i.e. at 4:48:01 pm. The wheel stop time was at 16 days 15 hours 9 minutes and 46 seconds of Mission Elapsed Time at 4:48:46 pm.

STS-67 was the longest space flight in the shuttle program and had travelled over 6.9 million statute miles.

Following their landing, the STS-67 crew returned to the Johnson Space Center in Houston. Endeavour was readied for a return trip to Florida aboard the 747 Shuttle Carrier Aircraft. Endeavour's next mission is STS-69 which is scheduled for July 1995. ■

KSC End of Mission Landing Weather Constraints

At decision time for the deorbit burn (about 90 minutes before landing), general weather restrictions for a KSC landing are specified in part as:

- Visibility must be five miles or greater;
- Peak surface winds must not exceed 20 knots in any direction;
- The peak crosswinds must not exceed 15 knots, 12 knots at night. If the mission duration is greater than 12 days the limit is 12 knots, day or night;
- The forecast and observed cloud ceiling must be 10,000 feet or higher. For scattered clouds below 10,000 feet, cloud cover must be observed to be not greater than 20 per cent;
- There can be no precipitation at the Shuttle Landing Facility or in the proximity of the orbiter's glide path;
- Thunderstorms, rain, or the potential for lightning cannot exist within 30 nautical miles of the landing site;
- Vertical cloud clearance at the 30 nautical mile range must be greater than 2 nautical miles.

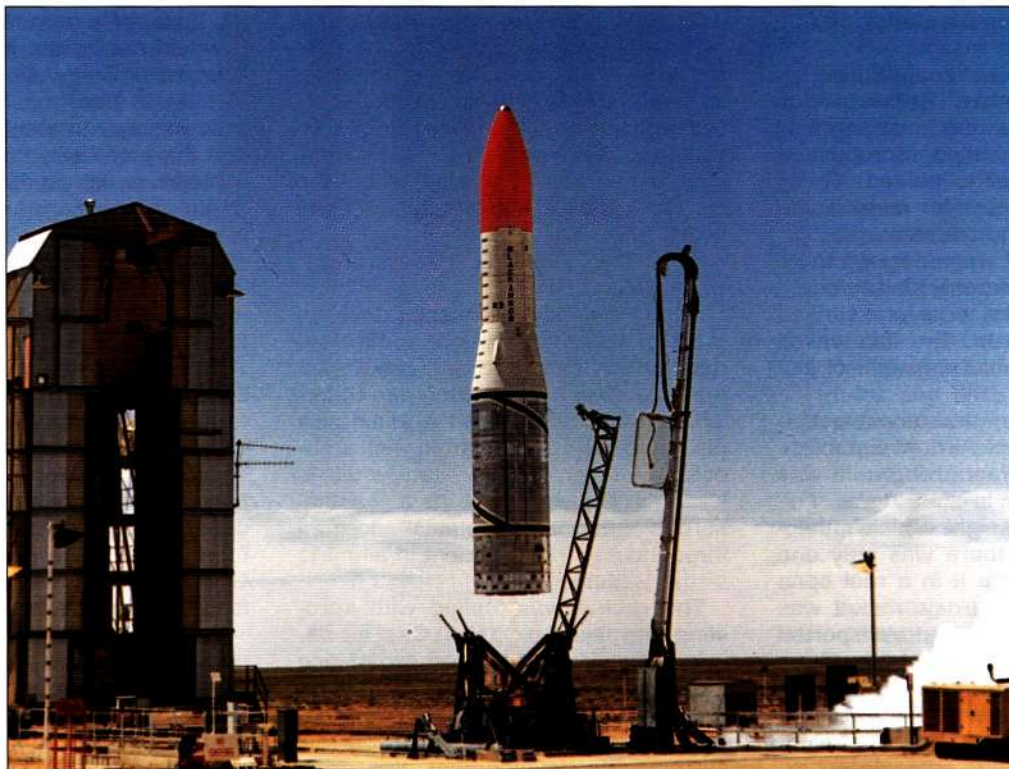
The Shuttle Landing Facility was built in 1975. It is 300 feet wide and 15,000 feet long with 1,000 foot overruns at each end. The strip runs northwest to southeast and is located about 3 miles northwest of the Vehicle Assembly Building.

25 Years Ago Saw the Last Europa Rocket Launch at Woomera

Woomera

Part 2: The Range in Action

During its heyday, the Woomera Rocket Range in South Australia was the most efficient range in the world. No other nation before had done so much as Australia with so little. In the June issue, Part 1 described the origins and development of the Range. We now take a look at the major rocket launchings and other activities that marked its years of operation and see that a question now arises, Is Woomera about to make a come-back?



The Black Arrow R3 launches Britain's Prospero satellite on 28 October 1971.

Introduction

The Woomera Rocket Range was designed as a military test range. Throughout its history, Woomera has been the test site of over four thousand missiles and three thousand bombs. Tested at Woomera were just about every form of explosive munition ever used in modern warfare, from a 25 pound iron bomb to rocket propelled anti-submarine torpedoes, to anti-aircraft rockets, to ballistic missiles. The range tested them all. But not all of the range's resources were devoted to tools of destruction.

Despite the fact that it was designed to test munitions, the range has a distinguished humanitarian history as well. The Woomera Rocket Range made possible several new technologies used throughout the world today, including computer tracking systems and new rocket technology. The range contributed to many fields of science. These include astronomy, atmospheric studies and manned space flight.

Perhaps the most memorable and public achievements of this facility are the series of tests by the European Launcher Development Organisation

BY ISAAC GRANT BOXX

NSW, Australia

(ELDO). All told, ELDO launched just eleven vehicles from Woomera in an effort to design and build an indigenous European satellite launcher. These included ten "Europa" vehicles and one of the highly successful "Black Knight" rockets. This is significant, in that last month marked the 25th anniversary of the launch of the "Europa f-9" rocket, the final ELDO launch at the range.

Although the programme was far from successful, these launches contributed to both space science and the development of technology for future space endeavours. In fact, these tests deserve a good deal of the credit for the highly successful European Ariane rocket series.

Black Knight

In the tumultuous beginning of the cold war, Britain [1] found that it was woefully short of experience in the area of ballistic missile design skills. After many short-sighted and frantic

efforts to regain lost ground in the missile race, Britain finally settled on the "Blue Streak" ballistic missile. This project was deemed too complex for Britain to attempt initially. Therefore it was decided that an intermediate technology development project was in order. Britain would design and build a smaller liquid fuelled research vehicle to test its ability in rocket development, in essence, a practise vehicle.

This vehicle soon became known as the "Black Knight". It is to this day one of the most successful and reliable rockets ever developed. Designed and manufactured in Britain for a cost of five million pounds in the mid 1950s, it was then used extensively at the Woomera Rocket Range in Australia. The vehicle itself was tiny by today's standards, yet it accomplished a great deal for both technology and science.

The vehicle was fuelled with kerosene and the highly volatile, ultrapure form of hydrogen peroxide known as "High Test Peroxide" (HTP). In fact, HTP is so volatile that it must be stored in airtight and surgically clean containers. This compound is so dan-

gerous that it must never touch human skin. More than one person has been killed handling this fearsome liquid.

The two compounds were fed in an eight-to-one ratio into "Gamma" engines by steam-driven turbo pumps. These engines, developed by the Armstrong-Siddeley Motors company had not one but four combustion chambers. The engine incorporated several new (at the time) technologies, giving it a high thrust-to-weight ratio. Despite all this, the "Gamma" engine was tiny by today's standards. The "Gamma" generated a paltry 16,000 pounds of thrust.

The design and manufacturing of these engines gave Britain much needed expertise in the emerging field of two-axis gimbaled combustion chambers, and turbo pumps. These are vital technologies for major liquid fuelled rockets and missiles.

This new rocket was designed to be so light that it could only stand upright when its fuel tanks were pressurised with compressed air. The thin walled vehicle had a structural weight of just 650 kg.

After its design and construction stages at the Royal Aircraft Establishment (RAE) at Farnborough, it was tested extensively in static tests. Following the Black Knight vehicle's theoretical validation there was only one thing left to do, test it in a real open air environment. The new rocket was loaded aboard a ship and transported to a port in Adelaide, Australia. From here it was taken to the town of Salisbury. After extensive testing and integration, it was loaded aboard a freight train to travel through great desert expanses until it finally arrived at Woomera, South Australia. At Woomera it would be integrated with a payload (usually a package of experiments or a mock nuclear warhead).

At last the Black Knight was ready for launch. It was pressurised and transported to launcher 5A. This particular site was designed solely for the Black Knight rocket experiments.

As with most rocket launch pads, the flame ducts of the pad were cooled by high pressure water hoses. Being situated in the middle of the desert, all water had to be piped in from great distances. Naturally obtaining the vast amounts of water required for this cooling technique caused some problems. After much deliberation, the range planners decided that the launch pads for the forthcoming (and much larger) "Blue Streak" missile would be placed on the edge of a cliff. The flame ducts would be carved beneath the pad, thus channelling the flame down the cliff face and away from the rocket. This ingenious technique eliminated the need for water cooling.

Although the Black Knight was merely a technology demonstrator, it

was a hugely successful vehicle in its own right. Over its ten year lifetime, it earned a reputation as one of the most highly reliable vehicles ever built. During its military career, the Black Knight simulated everything relevant to ballistic missiles from launch to warhead reentry. Soon after its initial military phase of operations was complete, it was decided the vehicle would be used as a general purpose research vehicle. It went on to assist research in areas of space travel from atmospheric to astronomy to hypervelocity aerophysics.

Another point to add to the list of highlights of the Black Knight programme is the fact that from the decision to build it to its first launch, only five million pounds were spent. To build and test a vehicle for such a low cost especially at a time when the technology was still forming was unheard of.

Blue Streak

After the hugely successful development of the Black Knight rocket series, Britain designed and developed the Blue Streak ballistic missile. Unfortunately this vehicle had a much less distinguished career than its predecessor. The vehicle was what is known in industry terms as a "cankerous bird". Problems formed throughout its development in all parts of the vehicle.

The rocket was fuelled with kerosene and liquid oxygen (LOX). Its development drew heavily on experience gained from the Black Knight programme. Blue Streak made use of similar radio control and telemetry systems. Its development also drew on the expertise gained from the design and manufacture of the Gamma engines. As with the Black Knight, the Blue Streak could not be moved without tank pressurisation.

It was finally seen by the British government, after it had expended a huge sum of money, that Blue Streak simply was not a feasible weapon. It required a great deal of maintenance. Test parts only worked occasionally and were far too expensive to produce on a large scale. The military version of the Blue Streak rocket was cancelled in April 1960.

The cancellation of the project was a potentially catastrophic blow to the Woomera Rocket Range. At the time of the cancellation the launch facilities had already been erected at massive expense in both money and time. The pad, known as Launcher 6A, had been built on an escarpment 45.7 m above Lake Hart, a dry salt lake. It had a 620 ton, 39.6 m movable servicing tower. Also built at the site were Australian designed vacuum flasks for the storage of LOX and a plant capable of producing 100 tons of LOX per week. As well as all this, the vehicle integration and test facilities had all been constructed. The cancellation of

the programme spelt a waste of years of effort.

Britain, realising that it would be a tremendous waste if it were to let the programme fold without anything to show for it, stepped back and took stock of the situation. It had a fully developed liquid fuelled rocket. It had a crew of highly skilled engineers now sitting idle. It had one of the world's best rocket facilities.

ELDO Vehicle

After intense deliberations, it was decided that Blue Streak could form the basis of a satellite launch vehicle. It would not be the first time this had happened. Both America and the Soviet Union had transformed their ballistic missiles to satellite launchers. In fact there are very few satellite launch vehicles in use today which did not begin their operational lifetimes as weapons. The Atlas, Titan and Delta series, for example, all began as ballistic missiles. This idea gained momentum. Preliminary talks were held in Strasbourg in February 1961. In November 1961, the European Launcher Development Organisation (ELDO) was formed. This organisation was dedicated to designing and building a satellite launcher for peaceful applications. Member-countries of this organisation included the United Kingdom, France, the (then) Federal Republic of Germany, Italy, Belgium, the Netherlands and Australia.

Each country was to control a small portion of the operations. For example, the first stage of the initial vehicle "Europa" would be the concern of Britain. The second stage would be the concern of France and so on. The responsibility for long range telemetry was given to Holland. Australia would provide the testing range.

The development of the "Europa" vehicle was based on the "Blue Streak" ballistic missile. A "Blue Streak" rocket would form the first stage of the three-stage rocket. Despite the fact that numerous static firing tests of "Blue Streak" had occurred, accumulating thousands of seconds of operational performance data, the actual "Blue Streak" missile itself had not been fired before the military programme was cancelled. Thus it was deemed necessary to test the vehicle's performance in a real environment. The first three launches, designated f1 to f3, in the Europa programme consisted of only the first stage of the vehicle, a "Blue Streak" rocket.

It was launched on June 5 1964. The f1 statistics were impressive. It stood 21.12 m tall and 3.05 m in diameter. With a liftoff thrust of 260,131 pounds and a liftoff mass of 205,453 pounds, the f1 vehicle was to have reached a height of 141 nm and a speed of Mach 12.9. The vehicle would have impacted 834 nm down-range. Unfortunately, these projections

did not materialise due to an early shutdown of the f1's engines. The f2 and f3 launches, however, were considered to be successful, and the programme continued.

In all, ten Europa vehicles were tested at the Woomera Rocket Range. Several attempts were made to place a satellite into orbit on this vehicle. As so often happens though, with the development of new launch vehicles, the development of "Europa" was plagued with difficulties. Of the ten Europa vehicles fired from Woomera, only three can be considered completely successful. Problems occurred during the other seven launches when the second stage failed to ignite, or when the third stage failed to ignite. First stage engines would shut down prematurely. Rocket stages refused to separate. Payload shrouds would fail to separate. Explosive bolts in the "safety systems" went off during flight.

The eyes of the Australian and international press, which gleamed with confidence and expectation at the start of the programme, were beginning to see red with the continued string of failures.

Finally, 25 years ago last month, mission planners decided to try to regain some faith in their programme with an attempt to orbit a satellite. After this, the programme would be wound down and moved to the newer launch facility at Kourou, in French Guiana.

After a series of delays and countdown postponements, the rocket finally lifted off the launch pad. After what appeared to be a completely successful launch, it became clear that all was not well. A heat shield had failed to separate from the rocket as planned and led to the rocket plunging headlong into the sea. This "partially successful" mission marked the beginning of the end of major launchings at Woomera.

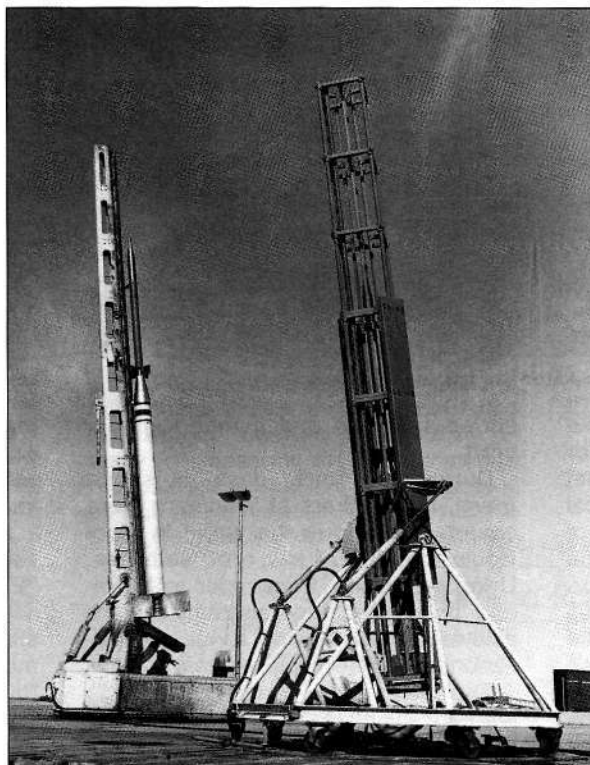
Black Arrow

Another major programme which took place at Woomera was known as "Black Arrow". The singular goal of this programme was to launch a British satellite on a British rocket as soon as possible.

In order to accomplish this, Britain created the Black Arrow, which was an extremely upgraded version of the Black Knight rocket. This new three stage rocket used as its propulsion plant multiple uprated "Gamma" engines (used by Black Knight). Naturally the vehicle used the same propellants and oxidisers. The rocket stood 13 m tall, considerably taller than the Black Knight. It also had twice the base diameter of the Black Knight. Many of the control and radio subsystems developed for the Black Knight were

converted for the Black Arrow. Even the same launch site, launcher 5 at Woomera, was used for both programmes.

Four Black Arrow rockets were fired from the Woomera Rocket Range between 1969 and 1971, resulting in the successful deployment of the "Prospero" satellite. This satellite was placed in an 82.1 degree, 547 x 1582 km orbit. Although another satellite was developed for launch aboard a fifth Black Arrow rocket, the programme was cancelled. The satellite,



High-altitude rockets at Woomera; The Cockatoo (left) and the Kookaburra (right).

known as X-4/Miranda, was launched by a United States "Scout" vehicle.

WRESat

Although Australia usually provided only the launch and recovery facilities for major programmes, there is at least one notable exception. This was known as WRESat. WRESat was an indigenous Australian satellite.

The spacecraft was designed and developed at the Weapons Research Establishment laboratories at Salisbury and the University of Adelaide in South Australia. This programme used a "Redstone" rocket, donated by the United States, as its launch vehicle. The satellite itself was designed and built in record time. From its inception to its launch, the entire programme took only eleven months. The fact that a country with no experience in satellite construction was successful on its first attempt was also a real eye-opener.

The satellite was launched on 29 November 1967. It remained in orbit for a baseline mission of five days (73 orbits), during which it transmitted data to the NASA global tracking net-

work. It stayed aloft for a total of forty-two days, completing 642 orbits. Unfortunately, this was a one shot deal. The programme was cancelled after that one launch. To date, WRESat remains the only Australian satellite launched from Woomera.

Skylark

A further project which took place at Woomera was the Skylark programme. This was perhaps the most prolific of the large rocket programmes undertaken at the range. It consisted of literally hundreds of rocket launches.

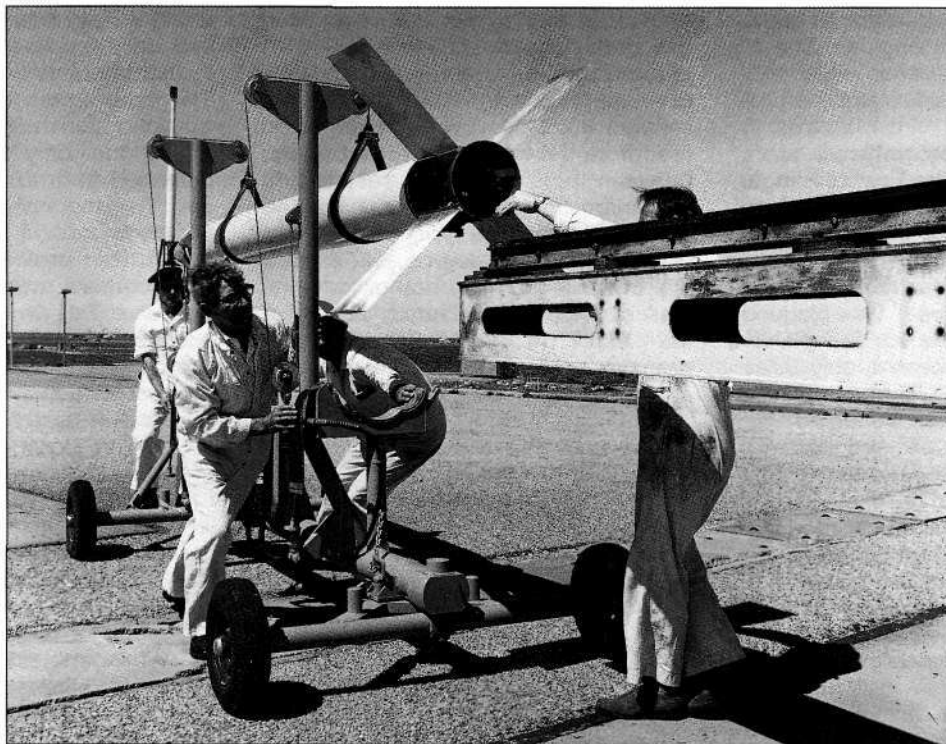
The Skylark project was based on the medium-sized British sounding rocket of the same name. Despite its whimsical sounding name, the Skylark was a real workhorse. This solid fuelled, unguided rocket was capable of taking a sizable package of experiments up to several hundred kilometres, depending on the payload and trajectory. The vehicle was used chiefly by university graduates, research institutes and WRE for upper atmosphere experiments. It was also indispensable as a training tool for many future rocket scientists. This vehicle made possible a great many early space discoveries.

Tracking Activities

Although its primary function was launching rockets and testing munitions, this was by no means all that Woomera did. Its secondary function was that of a tracking facility. Woomera excelled in the tracking of satellites by both optical and electronic means.

Due largely to the clear skies and flat terrain of the Woomera facility, much of the early tracking was done optically. Early rocket launches were monitored by many types of cameras ranging from wide field ballistic cameras taking just one frame to ribbon frame cameras working at a speed of one ten thousandth of a second per shot. Other camera systems such as the highly accurate and expensive Kine-Theodolite system and performance cameras were used to determine data such as pitch, yaw and roll.

A further point of interest about the range is that while women were traditionally absent from Woomera, and indeed from most of the early rocket ranges, much of the optical tracking was done by women. The major "Kine-Theodolite" network was operated primarily by women. This responsibility stemmed from the fact that women did much of the data input work in the computer tracking networks at Woomera, and thus it was necessary for them to be able to observe the launches first hand. These tracker/computer-operators made several new developments in the field of



Preparing for a Cockatoo launch in 1971.

optical tracking, including new computer software for optical tracking. For example, they developed a simple yet elegant and unique system for optical tracking. This system consisted of painting a candy cane stripe on the lower body of the rocket. By measuring the rate of movement of this stripe, one could easily determine the roll of the rocket. This helped increase the accuracy of trajectory analysis. This is another example of the many simple yet highly reliable techniques developed and used at the range.

Although optical tracking at Woomera became redundant after the installation of advanced radar, the extensive experience gained from optical rocket tracking helped to build a substantial technical capability. Gradually this expertise was transferred to the optical tracking of satellites. Using a "Baker-Nunn" optical tracking system, provided by the United States, Australia gained even greater expertise in tracking satellites and manned spacecraft. This system used an F-1 Schmidt telescope with a 50.8 mm focal length as an optical system and was highly effective throughout the world, but especially so in the hands of the experts at Woomera.

This team of trackers built a reputation respected throughout the world as highly reliable, imaginative and resourceful people who were adept at doing the impossible. Whenever a photograph of a satellite was required but very difficult to obtain, the experts at Woomera were called upon. Their "track" record was impressive. Among their many feats was the photographing of the 15.2 cm Vanguard 1 satellite whilst it was in a medium (4000 km) orbit. The team was also able to photograph several of the "Explorer"

series satellites and manned spacecraft.

During the early days of space travel, the trackers at Woomera were among the best in the world in electronic tracking of low orbit satellites. Using everything from radar to telemetry broadcast, the Australians were able to assist in a wide range of international satellite programmes.

The Woomera tracking facilities were invaluable to several of the early manned space travel launches. The Mercury missions were tracked from Woomera, both electronically and optically. Telemetry and verbal communications were relayed through this station. While verbal communications were not imperative to the operation of manned spacecraft, they helped enormously as a psychological boost for the lone astronaut.

With the cancellation of the Europa and Black Arrow programmes work at the Range was severely scaled back and the major launch facilities at the range remained idle. Some were intentionally destroyed to deter vandalism. Most of the instrumentation was packed up and shipped to Europe and the United States. Whatever was left was widely dispersed throughout Australia. Very little in the way of space-related work has since been carried out at the range.

A Possible Revival

In recent years however, an amateur group, The Australian Space Research Institute (ASRI) has been making use of the site to launch a series of developmental sounding rockets. The group is developing a radically advanced air-breathing rocket vehicle known as a Scramjet, for launch from Woomera. The group is also develop-

ing a recoverable sounding rocket capable of reaching 500 km with a payload of 100 kg. This too will be launched at the Woomera facility.

Recently, Woomera was to be the recovery site of the Japanese/German "EXPRESS" recoverable satellite. This satellite was to have conducted extensive microgravity and reentry experiments. Unfortunately for all involved, bad luck struck the project. Apparently due to a malfunction in the second stage of the rocket, the satellite failed to make it into orbit, falling into the ocean instead, and thus also failed to make it to Woomera. But the future of the Woomera facility is looking bright. It was recently announced that a major series of tests would be run at the site with the Japanese space agency NASDA. These experiments are in connection with the Japanese programme to develop an unmanned, recoverable space shuttle known as "HOPE". The details of the project are sketchy at present, but it could be the beginning of "a beautiful friendship".

Thus with a little luck and a lot of patience, the world may once again hear the roar of rocket engines from the land down under. And if that roar is successful as it was in the past, the whole of the space industry will benefit.

Acknowledgements

The author wishes to thank Mark Blair of the ASRI, and the Defence Science and Technology Organisation for their assistance in the acquisition of information and photographic materials for this article.

Reference

1. Roy Sherwood, 'Britain in Space', *Spaceflight*, May 1991, p.174.



Readers Write

Spacecraft Fires

Sir, The Russians think spacecraft fires are no big deal because they have had two or three fires on board their spacecraft that were easy to put out. In the past 20 years spacecraft fire extinguishers have been discharged six times for what the Russians describe as smoke incidents.

NASA officials explain that the Russians have provided information on fire incidents involving hardware that NASA considers relevant to the safety and reliability of joint US-Russian operations. The information the Russians have given NASA about Russian spacecraft fire suppression and warning systems seems to have satisfied NASA that the Russian hardware is safe and reliable. But is limited information enough? The Russians should inform their new partners about all of their experience with space fires.

The big deal is not fires in space, but smoke screens on Earth. If a topic as spectacular as a manned spacecraft fire can somehow be off limits, what else are we not being told? What are the future consequences of such ignorance for the health and well-being of tomorrow's spacefarers?

American space engineers are eager to find out all they can about the Russian experience with spacecraft fires. Now that the Russians are participating in the international space station, American astronauts will have to bet their lives on the competence and candour of Russian space workers.

Only a full disclosure of all such incidents, and the resulting countermeasures, will foster development of the earned trust that the international space station needs as its foundation.

JAMES OBERG
Texas, USA

(Excerpts of this letter are taken from *Space News*, Vol. 6, No. 9, March 6-12, 1995.)

Launch Times

Sir, I have noticed a consistent problem in the production of *Satellite Digest* which relates to round-off in the reporting of the launch date and time for launches that occur very close to midnight GMT.

Since I would imagine that the majority of readers are more interested in the launch date than the launch time, the reporting of such launches should be fixed at .99 rather than rounded up to the next day. While launches that would cause this problem are not frequent, neither would I categorise them as rare. I would greatly appreciate your attention to this problem. Thank you.

KEVIN SILKE
California, USA

Ed: The problem is being attended to as noted in *Satellite Digest* on p.252.

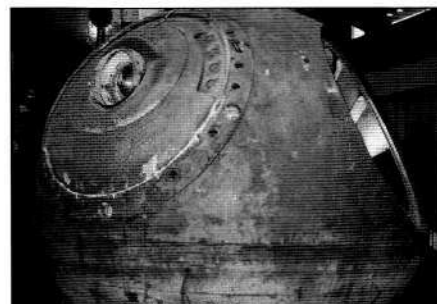
Voskhod 2 Air-Lock Hatch

Sir, The interesting article on the Voskhod 2 dramatical flight in the March 1995 issue of *Spaceflight* says on page 98 that "the plane surface seen on the outline is the second cabin hatch of which the air-lock was attached", when describing the photo of both Voskhod 1 and 2 capsules.

This is apparently a mistake because the Voskhod 2 second air-lock hatch was placed on the opposite side of the entry hatch, also visible in the photo. Therefore the plane surface must be the parachute container less its cover.

This corresponds very well with the "Vzor" optical orientation porthole seen in the Voskhod 1 interior in the same photo on the dark circle at 3 o'clock at the edge of the entry hatch. This porthole was part of another hatch of the original Vostok capsule and it was placed under the cosmonaut's feet during the flight. The position of the seats in Voskhod was rotated through 90° with the consequence that the entry hatch was then on the commander's right side and the Vzor porthole on the second (or third in the case of Voskhod 1) crewmember's left side.

It is known that the air-lock hatch was placed on Leonov's left side in place of the original Vostok technological hatch (*Spaceflight* June 1990, p.193). If the remark accompanying the photo was correct, Leonov would have to have had the air-lock above his head which was not so - see also the Voskhod 1 interior in the



The Voskhod 2 descent module. The plane surface, seen here on the right, is the open parachute container and is not related to the air-lock.

On the left is the hatch between the descent module and the air-lock. It contains a window for navigational purposes at deorbit. The flange to which the air-lock would be bolted encircles this hatch. The bottom of the sphere shows charring of the ablative heat shield.

Details of the Voskhod 2 air-lock appeared in an article by Dietrich Haeseler in *Spaceflight*, August 1994.

same photo.

The photo of Voskhod 2 with the air-lock containing the Vzor porthole appears in *Spaceflight*, August 1994, p.282. What we see then on the capsule's left side is the parachute container and not the air-lock hatch.

LAURENC SVITOK
Bratislava, Slovak Republic

Gamma-Ray SETI

Sir, Recently I was reading Marshall T. Savage's book *"The Millennial Project"* (which you reviewed some time ago). In conjunction with a news article on gamma ray bursts it inspired a rather 'off the wall' idea. On the very remote possibility that this has not already been proposed by somebody else and even remoter possibility that it is in fact correct I would like to present it to *Spaceflight* readers.

Even conservative estimates indicate that intelligent life should have evolved many times over in our galactic neighbourhood. Similar estimates indicate that a technological civilisation could colonise the galaxy in only a few million years, yet radio listening searches, from Ozma on, have found the sky empty of artificial radio emissions. But why should an advanced interplanetary or even interstellar civilisation use radio any more than we use smoke signals? Even earthbound space agencies are considering lasers as a means of communicating with deep space probes so why should our presumed million-year-old aliens be less sophisticated than NASA? Of course visible light lasers have disadvantages over interstellar distances - beam spread and light absorption by gas and dust. However, an advanced stellar civilisation would have all the resources of a solar system to draw upon. The power output of a single sun can be considered infinite as far as we are concerned and only a tiny proportion of that energy would be needed to power a gamma ray laser. At gamma ray wavelengths a modulated laser beam could achieve very high information density and be virtually immune to interference from

cosmic gas and dust. Of course there is the small problem of frying the recipient of your message but we may presume that a sufficiently advanced civilisation could solve that difficulty. Even gamma ray laser beams would spread a little so if we were surrounded by high energy stellar civilisations we should be able to detect their communications occasionally as short bursts of gamma rays when Earth gets 'caught in the beam'. Very like the mysterious bursts of gamma rays which hit us daily from all parts of the sky in fact. So, estimates say we should be surrounded by alien civilisations. We are surrounded by high energy bursts of gamma rays of mysterious origin. Perhaps the SETI searchers should pack up their radio telescopes and concentrate on finding very high frequency modulations in satellite detections of gamma (or even cosmic?) rays?

Well there we are. A very tenuous connection I know but intriguing even so. I do not know how original any of the above is but I would be interested in hear any comments through the pages of *Spaceflight*.

PAUL MCKINLEY
Dublin, Ireland

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Inflatable Antenna for 1996 Shuttle Launch

Space-based antennas, much larger than the size of current mechanical antennas, are soon to be in demand for a variety of space applications such as space-based radar, astronomical observing, active microwave sensing, Earth observation, mobile communications and many other applications.

An experiment to demonstrate the feasibility of the first large inflatable space antenna will be flown aboard Endeavour next year. The experiment which is being managed by NASA's Jet Propulsion Laboratory will be attached to a Spartan free-flying platform to be deployed on mission STS-77. Spartan will provide a mounting platform for the antenna together with its measurement system, power, attitude control and data handling systems.

A canister of nitrogen gas will be used to pressurise the inflatable antenna and full deployment should take no longer than five minutes. The deployment sequence will be monitored by two high-resolution TV cameras on the experiment and aboard Endeavour. Measurements of the parabolic mirror will then be taken to determine its surface accuracy and the stability of the structure.

The duration of the experiment will be only ninety minutes approximately after which the antenna will be separated from Spartan to burn up in the atmosphere. Spartan will be recovered by the shuttle and returned to Earth.

The antenna will be a 14 m diameter parabolic reflector supported by an inflatable ring structure at its edge. Inflatable struts will connect the antenna to the Spartan platform. The reflector membrane will be constructed from aluminised mylar while the struts supporting the dish will be neoprene-covered kevlar. The complete structure will weigh just over 100 kg and development will cost around the region of \$10 million, much less than for current space-based antennas.

This experiment will be the first step in the development of new, compact, low-cost, lightweight and inflatable space-based antenna systems and it is likely that testing of larger structures of up to 30 m diameter will follow.

KEITH T. WILSON

Japan's HOPE for Tests

Japan's machine-building company Fuji Zyukogio and commercial firm Sumomito Siozi have reached an agreement with Russia on comprehensive testing of a model of the Japanese space shuttle HOPE using equipment of the Russian Central Aerohydrodynamics Research Institute.

The first launch of an unmanned space shuttle is scheduled for 1999.

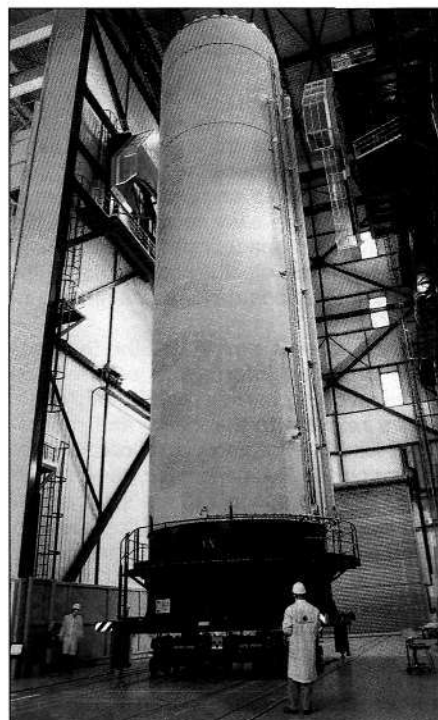
Tests Delay Ariane-5 Schedule

The first Ariane-5 launch scheduled for late November may be delayed until 1996.

On 27 January an important milestone was reached with the success of the last hot test on the launcher's cryogenic main stage in 'battleship' configuration (i.e. supported by heavy structure) at Kourou, French Guiana. A start was then made on the "M/Q" campaign, for which the battleship stage is replaced by one whose configuration is practically identical to that of a flight model with hot tests lasting 600 seconds (the nominal in-flight duration). The "M/Q" campaign will comprise five hot tests in the "M" (propulsion unit development) configuration and three hot tests in the "Q" (stage qualification) configuration.

On 5 May two technicians were asphyxiated during tests in the new Ariane-5 launch area. The cause of the fatalities was found to be a missing drainage plug resulting in a nitrogen leak and abnormally high nitrogen levels in the atmosphere. Tests were resumed before the end of May but the first on 22 May was aborted 39 s before ignition and the second on 31 May was stopped several seconds after ignition.

On 10 March, the sixth test and first qualification test on a P230 solid booster took place at the Guiana



The cryogenic tank for the cryogenic stage of the first Ariane 5 flight model arrived at Aerospatiale's integration building in Les Mureaux from Cryospace in January 1995.

AEROSPATIALE (Supplied courtesy THEO PIRARD)

Space Centre. A further qualification test is scheduled before the maiden flight of Ariane 5.

Soyuz Replacement

On 12 March, ITAR-TASS reported that work was gathering pace to replace the old and trusted Soyuz carrier rocket with a much improved version of the veritable booster - the "Rus", which has previously been described in *Spaceflight*, November 1993, p.370 by Charles Vick.

The new carrier rocket is scheduled to make its debut in 1997 from Plesetsk. However officials say that its launch and subsequent commissioning can only be accomplished if there is sufficient funding. A Soyuz rocket cost 900,000 roubles in 1979 when a (mostly military) annual order of 600 rockets drove the costs down. Now, however, the cost is 12 billion roubles each because only 15 are produced annually and rely upon Ukrainian-produced components in certain critical areas. "Rus" will use mainly Russian-produced components. Because of these difficulties recent launches to supply Mir have used "borrowed" Soyuz and other versions of the basic rocket from a military stockpile.

NEVILLE KIDGER

US Buy Station Module

On 10 February a protocol was signed between NASA and the Russian Space Agency (RSA) approving the US purchase for \$190 million of Russia's Functional Energy Block (FEB), the first element of the International Space Station to be built as from 1997.

After initial use as a propulsion module, the FEB will serve as a fuel storage module and a service area, which will provide living and experimentation space as well as back-up guidance, navigation and control. In addition, the FEB will serve as an integral part of the space station's overall power and information subsystem.

The protocol guarantees, with no additional cost to NASA, the launch of the FEB on a Russian Proton booster, navigational control in orbit and related engineering, integration, logistics, maintenance and training support for the FEB. The purchase agreement, as a subcontract to NASA's prime space station contractor, Boeing, calls for the design, development, manufacturing, test and delivery of the FEB.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-71	23 June	Atlantis	11 Days	Mir-01 Mission	51.6
STS-70	To be decided	Discovery	8 Days	TDRS-G	28.5
STS-69	20 July	Endeavour	11 Days	WSF-2, Spartan 201-03	28.5
STS-73	21 September	Columbia	16 Days	USML-02	28.5
STS-74	26 October	Atlantis	6 Days	Second Mir docking	51.6
STS-72	30 November	Endeavour	9 Days	Retrieval of SFU (Japan launch), Spartan/OAST free flyer	28.5

Woodpeckers Make STS-71 Next Shuttle Launch

STS-71, the first Shuttle/Mir docking mission is again set to become America's 100th crewed space mission.

After an initial switch of flight rotation with the STS-70 mission the antics of a pair of woodpeckers have given the docking mission the chance to set yet more historic records.

The pair of mating flicker woodpeckers decided to roost near the STS-70 stack and pecked 135 small holes in the External Tank's thermal shielding. After an examination of the damage NASA officials decided to roll the stack back to the Vehicle Assembly Building for repairs, thus delaying the mission for over a month and making the Atlantis mission the next on the flight roster.

Uncertainties regarding the launch date of the Spektr add-on module for the Mir station, the presence of which was a requirement for the STS-71 mission to proceed, had previously led NASA managers to decide to launch the STS-70 mission first on the orbiter Discovery to deploy the TDRS-G satellite. STS-70 is to be the first flight of the new Block I Space Shuttle Main Engine (SSME) with the new Phase II+ powerhead, single coil heat exchanger and new high pressure oxidizer turbopump. Mission planners were also considering cutting the flight time of STS-70 from 8 to 5 days to give more time for Atlantis preparations.

At 0343 EST (0843 GMT) on 26 April, Atlantis, stacked on the huge Crawler and mated to the External Tank and the Solid Rocket Boosters, began the trek to Pad 39A. Despite the plan to launch Discovery first, Atlantis was rolled to the launch pad on schedule. By the end of the day the stack was on the launch pad with the interface verification tests completed and validations of the launch pad underway. Next day saw the completion of the hot firing of the Auxiliary Power Units on Atlantis.

Driving their traditional convertibles to Pad 39B on 18 May are Mission specialists Don Thomas and Nancy Currie who look on as STS-70 Pilot Kevin Kragel is greeted by launch commentator George Diller.

PETER GUALTIERI, WEST KENTUCKY NEWS



The crew of STS-71 and Mir-19 at Pad 39A during the Terminal Countdown Demonstration Test (TCDT) on 24 May. Left to right are STS-71 Commander Bob 'Hoot' Gibson, Pilot Charles Precourt, Mission Specialists Ellen Baker, Greg Harbaugh and Bonnie Dunbar, Mir 19 Commander Anatoly Solovyev, Cosmonaut Nikolai Budarin and their back-ups Yuri Onufrienko and Yuri Usachev. The Mir-19 crew are to be taken to Mir by Atlantis which will then return the Mir-18 crew to Earth. This photo was taken in the Slide Wire Escape Basket Deceleration Area with Atlantis wrapped in the Rotating Service Structure of Pad 39A.

PETER GUALTIERI, WEST KENTUCKY NEWS

Preparations were underway for the main propulsion system helium signature test and hypergolic fuelling operations.

Early May saw hypergolic fuelling preparations occupy the ground processing team and the hydraulic systems were checked. On 8-9 May preparations were underway to load the storable propellant into the orbiter and the thermal curtains were being installed on the Solid Rocket Boosters. Next day propellant loading began. By 15 May the operation was completed. Preparations were beginning for the main engine Flight Readiness Test scheduled for 17-18 May and the Terminal Countdown Demonstration Test scheduled for 24-25 May.

On 16 May NASA revised the launch date to no earlier than 22 June and subsequently, following the Flight Readiness Review, targeted it for close to 5:06 pm EDT on 23 June with docking on 25 June. The landing is set for 4 July at the Kennedy Space Center.

NEVILLE KIDGER

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The British Interplanetary Society
SPACELINE



Candidate Payload Specialists Selected From France, Canada, Spain and Italy

A 16-day international Life and Microgravity Science (LMS) Spacelab mission is scheduled for launch aboard the orbiter Columbia in mid-1996. Experiments will be carried out for investigators from the United States, several European countries and Canada. Twenty-four investigations are planned. Of these, eighteen are from the life sciences and six are from the field of microgravity research. Most of the experiment facilities have been flown on previous Spacelab missions.

On 8 May NASA announced the assignment of Jean-Jacques Favier and Bob Thirsk as the two payload specialists and Pedro Duque and Luca Urbani as their backups.



Jean-Jacques Favier.
NASA

Dr Jean-Jacques Favier, born 13 April 1949, is one of the second group of astronauts of the French Space Agency CNES selected in September 1985. In 1991 he was one of the six proposed French candidates for the selection of new European

Space Agency (ESA) astronauts. However before the actual selection process had started, his candidature was cancelled because of a five person limit for each ESA member state.

Dr Favier served as an alternate payload specialist for the STS-65/IML-2 mission flown in July 1994. He was a scientist of CENG (the Nuclear Centre in Grenoble, France) and principal investigator for the MEPHISTO experiments on STS-52. Recently he joined the staff of the Center for Microgravity and Materials Research at the University of Alabama in Huntsville.

Dr Robert (Bob) Brent Thirsk, a medical doctor and an adjunct professor at the University of Victoria, born 17 August 1953, is one of the six Canadian Space Agency (CSA) astronauts selected in December 1983. He served as backup crew member for STS-41G which flew on 5-13 October 1984. Dr Thirsk regularly participates in parabolic flight experiments on board NASA's KC-135 aircraft. In February 1994, he was crew commander for the Canadian Astronaut Program Space Unit Life Simulation (CAPSULS), a simulated 7-day space mission in which four Canadian astronauts participated.



Bob Thirsk. CSA

His name was more than once mentioned in connection with a projected Soyuz spacecraft flight to the Russian space station Mir. However Major Chris Hadfield, another CSA astronaut and qualified mission specialist will be the first Canadian to fly to Mir on Space Shuttle STS-74 in November 1995.

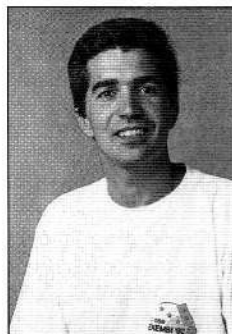


Pedro Duque. ESA

Dr Pedro Duque, born 14 March 1963 at Madrid, Spain, was selected as an ESA astronaut in May 1992. After completing introductory and basic training programmes at ESA's Astronauts Centre (EAC) in Cologne (Germany) and at the Cosmonauts Training Centre (ZPK) at Star City (Russia), he started training in August 1993 in preparation for the EuroMir 94 mission. Eventually he served as the backup crew member for ESA astronaut Ulf Merbold on that mission which flew on 3 October - 4 November 1994.

Dr Luca Urbani, born 11 May 1957 at Rome, Italy, is a medical officer of the Italian Air Force, Medical Corps (current rank: Lieutenant Colonel). Being one of five Italian candidates, he belonged to the 25 finalists in the selection of new European Space Agency (ESA) astronauts in 1991/92, but eventually he was not selected (See *Spaceflight*, July 1992, p.219 and p.236).

Dr Urbani participated, as a member of the Experimental Programme Execution Team and as a principal investigator for one of the physiological experiments, in the ESA project EXEMSI '92, a long duration ground simulation of a manned space mission performed at Cologne in 1992. In February 1994 he was one of the crew members to the Columbus Utilisation Simulation (CUS '94 campaign) also a simulation of a long duration space flight.



Luca Urbani. DLR/ESA

NASA has also named three mission specialists for the STS-78/LMS-01 flight: Susan J. Helms (Lt. Col. USAF), Dr Richard M. Linnehan and Charles E. Brady, Jr (Commander, USN). The assignments of the commander and pilot are expected at a later date.

ROLF SCHOEVAART

Russia Loses Three Satellites

On 28 March, the Russian Kompleks firm launched three more satellites on a single carrier rocket but failed to place them into orbit.

The "Start" carrier rocket (based on the "Topol" SS-25 ICBM) was launched from a mobile launch carrier from the Plesetsk cosmodrome at 0900 GMT on its first commercial flight.

The satellites carried were :

- EKA-2, a Russian miniature comsat weighing 202 kg;
- Gurwin-Techsat-1, a privately sponsored satellite for the Space Technology Institute of Haifa, Israel weighing 55 kg;
- Unamsat, a joint Russian/Mexican satellite weighing 12 kg for Moscow University.

The EKA-2 resembles a barrel 130 cm long with a diameter of 1 m, according to ITAR-TASS. The payload replaced a planned South African satellite - "Greensat" which was cancelled due to lack of funds.

The five-stage solid-fuelled "Start" rocket, on its second space mission, was aiming for a 700 km orbit inclined at 78 degrees but early attempts from Moscow and Haifa to contact the payloads were futile.

The rocket was thought to have plummeted into the Sea of Okhotsk after the failure of its fifth stage. The Israeli space agency head G. Shaviv said initially that they might ask for their money back after the failure. The Israeli satellite Gurwin-Techsat-1 was financed by private funds - mostly by an ex-Soviet Jewish emigre, whose name the satellite bore, to the tune of \$1 million. The initial snag in determining the fate of the "Start" and its three satellites appeared to be lack of telemetry. The fifth stage ignited over the horizon of the Russian Space Forces tracking station. However a report quoted by the Russian agency said that the failure of the fifth stage engine 10 minutes after launch caused the loss of the payloads.

NEVILLE KIDGER FBIS

Delta III Development

On 10 May, McDonnell Douglas announced the development of the Delta III, a next generation expendable launch vehicle with a planned first launch in 1998. The payload capacity of the Delta III will be 8,400 pounds to geosynchronous transfer orbit, more than twice the capacity of the Delta II.

The initial customer for Delta III launches is Hughes Space and Communications International with whom McDonnell Douglas have signed a contract for 10 firm launches, plus options for additional launches to 2005.

The new rocket will be capable of launching Hughes' largest model, the HS601. The most significant changes in Delta III's evolution from the existing Delta II are a new single-engine, a cryogenically propelled upper stage and a larger fairing to house the payload.

‘Cassini Spacecraft’ Competition

The development of the Cassini Project made excellent progress in 1994 in preparation for its scheduled launch in October 1997 to Saturn and its major moon, Titan. Cassini's objective, beginning in June 2004, is a four-year study of the Saturnian system, including Saturn's atmosphere and magnetosphere, its rings and several moons. Cassini will carry a European-built probe, named Huygens after the 17th century Dutch scientist Christian Huygens, which will be sent into Titan's atmosphere and land on its surface.

This month's competition asks readers to identify some of the main components that make up the Cassini spacecraft.

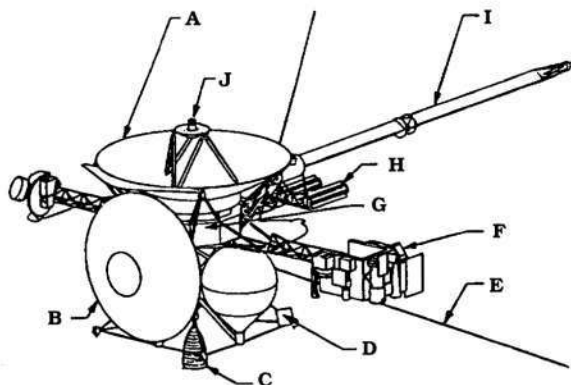
Prizes: The first five correct entries to be opened after the closing date of 3 August 1995 will receive a copy of the new video from the BIS Video Collection:

STS-63 Mission Highlights

For details of this video and those of other Space Shuttle missions, please see the inside front cover.

To Enter: Identify the following 10 components of the Cassini spacecraft by entering the appropriate letters in the spaces provided:

- | | |
|---|-------|
| 1. Titan probe | ..... |
| 2. Main engine | ..... |
| 3. High Precision Scan Platform | ..... |
| 4. Electronics Bus | ..... |
| 5. Low gain antenna | ..... |
| 6. Magnetometer boom | ..... |
| 7. High gain antenna | ..... |
| 8. Calibration target | ..... |
| 9. Plasma/Radio Wave Spectrometer Antennas | ..... |
| 10. Radio-isotope Thermoelectric Generators | ..... |



**Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England**

To arrive by first delivery on 3 August 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

***Tapes are VHS PAL format only and are not compatible with the US NTSC system.**

Title/Name

Address

.....
.....

Acknowledgement: The diagram shown above is based on information taken from the ESA/NASA Report on the Cassini Phase A study.

Spaceflight Crossword

No. 23

ACROSS

1. Canadian communications satellite
3. Shuttle work-place for experiments
9. First American to orbit Earth
10. He trained for STS-45 but did not fly for medical reasons
11. Centre of cyclone
13. Peoples
14. Empty space
16. Departure
18. Times of year when Sun reaches a turning-point
20. US Space Shuttle (acronym)
22. Cosmonaut assigned to Atlantis
23. Large southern constellation
25. Writer
26. Matures

DOWN

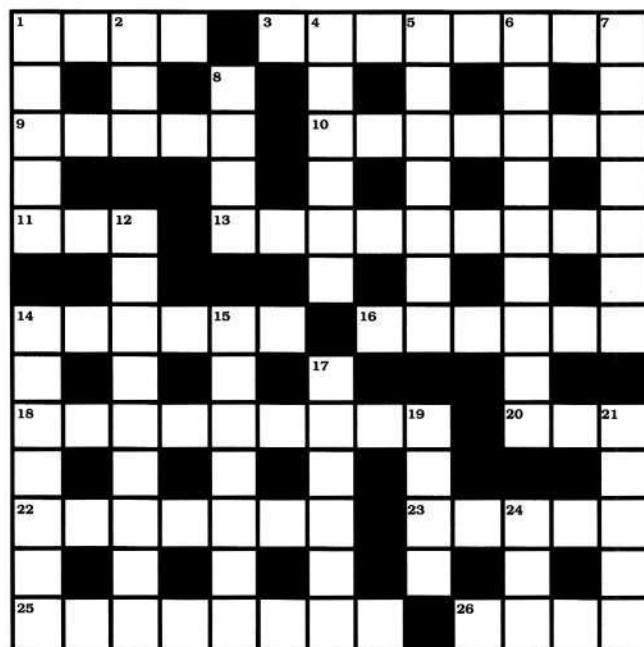
1. Inclination
2. Long-serving astronomical satellite (acronym)
4. Indonesian communications satellite
5. Collection of interrelated buildings as at launch site
6. Angular distances from equator
7. Extra dividends
8. Photograph hastily taken
12. Satellite of Saturn
14. Capable of being seen
15. Extremely
17. Cakes
19. ESA satellite to study Sun from a Lagrangian Point
21. Gaseous masses generating heat and light
24. Excavate

Solution will appear in the August issue.

Solution to Crossword No.22.

ACROSS: 1. Cloud; 4. Program; 8. Allegro; 9. Dated; 10. Fudge; 11. Perform; 13. Eats; 15. Expose; 17. Stasis; 20. Rear; 22. Tractor; 24. Ample; 26. Alert; 27. Cossack; 28 Ensures; 29. Theme.

DOWN: 1. Chaffee; 2. Oiled; 3. Degrees; 4. Prompt; 5. Order; 6. Retools; 7. Modem; 12. ESSA; 14. Aero; 16. Planets; 18. Transit; 19. Speckle; 21. Erects; 22. Trace; 23. Tutor; 25. Plane.



SATELLITE DIGEST-278

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Design	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
ORBCOMM 1	1995-017A	Apr 3.58	WE	Pegasus	40	Apr 3.89	69.99	99.67	736	749	[1]
ORBCOMM 2	1995-017B				40	Apr 4.24	69.99	99.62	734	747	
MICROLAB 1	1995-017C				68	Apr 4.17	69.98	99.63	733	749	[2]
Ofeq 3	1995-018A	Apr 5.47	Palmachim	Shavit	225	Apr 5.79	143.38	95.63	368	730	[3]
AMSC 1	1995-019A	Apr 7.99	ER	Atlas-2A	2,700 ?	Apr 19.62	0.09	1,435.68	35,760	35,797	[4]
Progress-M 27	1995-020A	Apr 9.82	Tyuratam	Soyuz	7,250 ?	Apr 12.05	51.65	92.41	389	396	[5]
ERS 2	1995-021A	Apr 21.07	Kourou	Ariane 40	2,516	Apr 27.77	98.55	100.54	783	785	[6]

NOTES

- ORBCOMM satellites use Orbital Sciences Corporation MicroStar satellite platform. Satellites launched for communications, but reportedly the satellites developed problems in orbit.
- MICROLAB 1 is based upon the MicroStar satellite platform; carries Optical Transient Detector for the study of lightning and understanding of major atmospheric storm systems and a GPS meteorological experiment to study the occultation of GPS signals.
- Third satellite launch from Israel. Ofeq series is reportedly a test-bed for future reconnaissance systems, and Ofeq 3 is widely reported to have carried an imaging system. At the first pass through apogee an on-board propulsion system ignited to raise the perigee of the orbit - the first time that an Israeli satellite had manoeuvred in orbit. Planned final orbit is approximately 500 km circular, although no further manoeuvres had taken place through to the end of April 1995.
- AMSC 1 is a communications satellite using Hughes HS-601 bus, operated by American Mobile Satellite Corporation (AMSC) for mobile telephone communications; also called MSAT 2. Mass quoted above is at launch: on station it is initially approximately 1,650 kg, with a dry mass of approximately 1,270 kg. Satellite is to be operated over 259 °E.
- Unmanned cargo freighter, carrying supplies to the cosmonauts aboard the Mir Complex. Spacecraft docked with the front port of the Mir Complex Apr 11.88. When Progress-M 27 is de-orbited at the end of its mission it is thought to be deploying the Raduga capsule launched in November 1994 aboard Progress-M 25.
- Second "European Remote Sensing" satellite to be launched. Prime contractor was DASA/Dornier GmbH in Germany. Primary mission comprises remote sensing of the Earth's oceans, atmosphere, ice and land in the microwave, infra-red and visible wavelengths.

1994-053A Cosmos 2290 was de-orbited and decayed April 4. If it came down on a pass which would have allowed part of the craft to be recovered then the decay would have been April 4.7-April 4.8.

1994-086 Launch date and time of Cosmos 2299-2304 (1994-086A-F) should be 1994 December 26.94.

1995-010A Launch time of Soyuz-TM 21 should be 1995 March 14.26.

1995-011B Add the following geosynchronous orbit for Himawari 5:- April 9.20, 1.05°, 1,436.14 minutes, 35,787 km, 35,788 km. The satellite is located over 159-160 °E.

1995-013A Add the following orbital data for INTELSAT 705:- April 7.60, 0.03° 1,436.02 minutes, 35,618 km, 35,952 km. The satellite was located over 303-304 °E. On April 27 the satellite was manoeuvred off-station and started to drift to the east.

1995-016A Add the following orbital data for BRASILSAT B2:- April 7.70, 0.14°, 1,435.90 minutes, 35,762 km, 35,803 km. The satellite is located over 298-299 °E.

1995-016B Add the following orbital data for Hot Bird 1:- April 9.65, 0.04°, 1,436.18 minutes, 35,779 km, 35,797 km. The satellite has been located over 11-12 °E.

START LAUNCH FAILURE

ITAR-TASS stated that the intended orbit for the three satellites carried aboard the Start launch vehicle which failed to reach orbit on March 28 1995 was inclination 78°, altitude 700 km (presumably a near-circular orbit was intended).

TIME TO TWO DECIMAL PLACES

Two decimal places of a day for the launch time were used before I started to compile *Satellite Digest*. However, in continuing the *Digest* I decided to follow the practice of previous compilers. Originally the format was chosen because compilers used the launch times quoted in the *Table of Earth Satellites* which was issued from the former Royal Aircraft Establishment in Farnborough until the completion of 1992 launch coverage. Of course, this format does lead to problems when a launch takes place a few minutes before midnight GMT as the process of rounding off to two decimal places moves the day date on to the next day. I think that the simplest solution will be for me to state in these *Notes* when a launch was shortly before midnight GMT and thus on the day previous to the one shown in the orbital data table above.

As an aside, the former RAE decided upon the "two decimals of a day" format because originally the overwhelming majority of launch times were not announced. While it was possible to calculate estimates of launch times from tracking data, the RAE did not feel that an accuracy greater than ±0.01 of a day could be placed on the results - hence times were quoted to two decimal places as the standard format.

PHILLIP S. CLARK

ADDITIONS AND UPDATES

- 1967-043B Hitchhiker 14/OPS 1967 decayed 1993 March 14.
- 1977-048A GEOS 2 stabilised its orbit over 185-186 °E during April 12-21.
- 1979-098B DSCS-2 14 was boosted off-station over 85 °E approximately April 12. It was still drifting at the end of the month.
- 1986-017JE Add a German satellite ejected from the Mir Complex during April 19-20. GeoForschungsZentrum 1 (GFZ) is a laser-reflecting geodetic satellite, built by Kaiser-Threde in Germany. It was launched aboard Progress-M 27 (1995-020A). Add the following orbital data:-1995 April 20.06, 51.65°, 92.34 minutes, 384 km, 394 km
- 1991-021A Cosmos 2137 decayed from orbit 1995 April 3.
- 1993-060A Cosmos 2264 was manoeuvred off-station 1995 April 4 and has been retired. Add the following orbital data (the first is the operational orbit):- April 4.28, 65.01°, 92.78 minutes, 401 km, 421 km April 4.85, 65.03°, 91.13 minutes, 268 km, 392 km April 5.04, 64.99°, 90.85 minutes, 240 km, 393 km The satellite is now decaying from orbit. This leaves Cosmos 2293 (1994-072A) as the sole operating EORSAT.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

10 July 1995

7 - 8.30 pm

Australia in Space

J. Heyman

Western Australia

The lecture will commence with a discussion of Australia's early space history, including the development of Woomera, the sounding rocket programmes conducted at Woomera, the involvement with the British and ELDO space programmes, the cooperation with the US and the launch of Australia's own Wresat satellite.

The lecture will then discuss the limited activities from Wresat until the 90s and will finally have a look at the recent five year space plan promulgated by the Australian Space Council.

6 September 1995

7 - 8.30 pm

STRV Satellites: Mission and Results

Dr Andrew Sims

DRA Farnborough

On 17th June 1994, two small satellites built by the Defence Research Agency were launched from Kourou, French Guyana as auxiliary payloads on Ariane flight V64. Placed into Geostationary Transfer Orbit, the mission of the two 52kg "Space Technology Research Vehicles" is to demonstrate the in-orbit performance of novel technologies and to make supporting measurements of the space environment. The talk will focus upon lessons learned from the new technologies - both during development and in-orbit and on results from a variety of radiation monitors flown on both satellites.

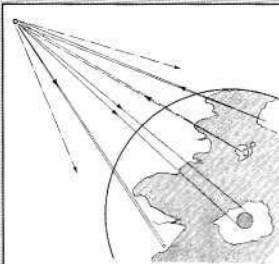
22 November 1995

7 - 8.30 pm

SAREX

Mr Will Marchant

The Shuttle Amateur Radio Experiment (SAREX) is an amateur radio station flown on about half of the NASA Space Shuttle Missions. It is primarily used for contacts between the astronauts and school students during the mission. The speaker will present a SAREX related slide set that he has created for use by NASA Educational Personnel.



ENJOY AN EVENING WITH ARTHUR C. CLARKE

at

The Scientific Societies Lecture Theatre,
Fortress House,
New Burlington Place, London W1

at 6.30 pm on 18 August 1995

The Society will present its Space Achievement Medal to

Arthur C. Clarke

in honour of his work, together with a special commemorative plaque to mark the 50th Anniversary of the concept of geostationary satellites advanced by Arthur in 1945.

◆ Buffet Reception

◆ Guest Speaker

Tickets are available to members at £20 per person. Early application should be made to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

In the event that Arthur is unable to attend for health reasons he will be participating by satellite link from Sri Lanka.

7 December 1995

7 - 8.30 pm

Space, The Medical Challenge

Dr Mike Harrison

*Defence Research Agency Centre for
Human Sciences, Farnborough*

Radiation, vacuum and absence of gravity combine to make space an environment that is overwhelmingly hostile to life. Add confinement and isolation in a fragile habitat, a vulnerable life support system, and the remoteness of help and rescue, and you have the ultimate human challenge - the permanent occupation of space. The talk addresses some of the key medical issues involved in responding to that challenge.

IAF CONGRESS

Benefits of Space for Humanity

The 46th IAF Congress of the International Astronautical Federation will be held in Oslo, Norway, 2-6 October 1995.

Details of the programme are available from the Society. Please enclose a 19p stamp.

12 August 1995

50th Annual General Meeting

The 50th Annual General Meeting of the Society will be held at The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1, on Saturday, 12 August 1995 at 12 noon.

Admission is by ticket, available to Corporate Members (i.e. Fellows of the Society) only, who should apply in good time enclosing a stamped addressed envelope.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

13 September 1995

10 - 4.30 pm

Low-Cost Satellites

Many organisations have been trying to reduce costs substantially, mainly by the innovative design of micro- and minisatellites. Some of the topics relevant to this theme will be presented.
Organiser: Dr D.G. Fearn

27 March 1996

10 - 4.30 pm

Call for Papers

Space Transportation

For over a decade the BIS has run symposia on the subject of space transportation. These are intended to provide a forum to cover all aspects of the space infrastructure including the rationale for infrastructure development, system concepts and technology issues. In the past these symposia have been key to the development of HOTOL, Skylon, the Polar Platform and UK thinking on space industrialisation as a part of mankind's future.

Organiser: Mark Hempell

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

The RAE Table of Earth Satellites, 1957-1989

1056 pages, published in 1990. Original price £95.

The Society has acquired a stock of the RAE Table of Earth Satellites, a substantial volume originally published at £95 which it is now making available to members at the incredible price of £7.50 (US\$15), plus £4.50 postage and packing in the UK. £9 (US\$16) abroad.

Send to: The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, England.

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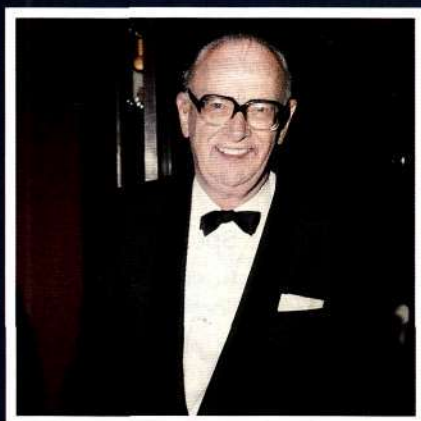
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Dr Arthur C. Clarke, CBE
Fellow of the British Interplanetary Society

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The Society was founded in 1933 and is the world's longest-established organisation devoted solely to the exploration of space and astronautics. It has charitable status and obtains most of its income from its membership being financially independent.



(A photocopy of this form may be submitted)

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- or an official Society pin-on lapel badge ☐+
- or a copy of the book by Robert C. Parkinson "Citizens of the Sky" ☐+

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- (b) £57 (US\$103) for an 18 month subscription from July 1995 to December 1996 ☐

Reduced rates are available for those under 22 or of 65 years or over. For (a) the amount is £26 (US\$47). For (b) the amount is £39 (US\$71).

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Mir Rendezvous

STS-63 Mission Highlights

Launch Date: 3 February 1995

The 20th orbital flight of Discovery. The crew included as mission specialists Russian Vladimir G. Titov, Janice Voss and British born C. Michael Foale. The prime objective of the mission, and the first stage in the American-Russian space station programme, was to make a close rendezvous with MIR to test the procedures to be used on Mission STS-71 to dock the shuttle with the space station. STS-63 carried Spacehab-3 science module and the SPARTAN-204 deployable/recoverable astronomy satellite. Other experiments included CSE (Cryo Systems Experiment), GLO-2 (Shuttle Glow Experiment), ODERACS-2 (Orbital Debris Radar Calibration Spheres). The video runs for approximately 1 hour and includes some spectacular rendezvous images of the MIR space station.

STS-65: Mission Highlights

Launch Date: 8 July 1994

STS-65 was the 17th trip into space made by space shuttle Columbia which spent 14 days in orbit. The mission conducted a wide range of experiments concerned with biochemical, biological and human physiological processes in reduced to zero-gravity environments. The science crew included for the first time a Japanese woman as a mission specialist. The second International Microgravity Laboratory (IML2) science programme was made up of a number of experiments ranging from protein separation and electrophoresis, to the study of growth and breeding of fruit-flies in zero to 1G variable-gravity environments. The effects of zero-G on the swimming orientation of goldfish, and the behaviour of adult Japanese Red Bellied newts and the growth of their embryos were among a range of aquatic experiments performed in a special unit called the AAU (Aquatic Animal Experimental Unit) which was probably the first equivalent of an aquarium in space. The video includes some excellent views of Earth. There is only a limited sound commentary.

57 mins

STS-64: Mission Highlights

Launch Date: 9 September 1994

The 19th flight of Discovery conducted a diverse range of experiments concerned with Earth environment monitoring technology. The mission included the release and recovery of the 2800 pound SPARTAN satellite. The mission included extended EVA activities. Nitrogen propellant recharging of the astronauts' manoeuvring unit, the SAFER (Simplified Aid for EVA Rescue), is shown. Its manoeuvring ability and its attitude control system are impressively demonstrated. The mission also included a series of atmosphere monitoring experiments with the Lidar in Space Technology Experiment (LITE) instrument.

1 hr 4 mins

STS-60: Mission Highlights

Launch Date: 3 February 1994

This Discovery mission included Russian cosmonaut Sergei Krikalev and marked the start of a new era of USA and Russian cooperation in Space. The mission carried the Spacehab module and a three-dimensional gravitational accelerometer. Other experiments included the study of crystal growth under zero-G, the deployment of BREMSAT and the launch of six Orbital Debris Radar Calibration Spheres (ODERACS), ranging from 5 to 15.2 cm in diameter.

58 mins

STS-59: Mission Highlights

Launch Date: 9 April 1994

Perhaps the most challenging part of this shuttle mission was experiment SRL1, the first flight of the Space Radar Laboratory. To study the surface of the Earth with this instrument package Endeavour was required to make more than 400 separate position manoeuvres to achieve the ground track and orbiter alignment essential for radar mapping the surface and geology of the Earth. Other important tasks included tests of a new form of video-microscope capable of studying biological processes, such as cell growth and movement, under zero-G conditions. Pollution studies included mapping the global and local distributions of CO important in the study of ecology and the ecosphere. There are a number of spectacular SRL1 Earth views.

59 mins

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☐ Challenger: Accident Investigation	£11	(US\$20)
☐ STS-26: The Return to Flight	£15	(US\$27)
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☐ STS-32: The Recovery of LDEF	£15	(US\$27)
☐ STS-37: Video Highlights	£15	(US\$27)
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☐ STS-58: Mission Highlights	£15	(US\$27)
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JBIS



The August 1995 issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

Mars Exploration (Part II)

Report on the Construction and Operation
of a Mars *In Situ* Propellant Production Unit

Mars *In Situ* Propellant Technology Demonstrator Mission

Design of a Water Vapor Adsorption Reactor
for Martian *In Situ* Resource Utilization

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Soviet Space Secrets

In the five years between James Oberg's two visits to the Baikonur Museum, major changes have occurred. Now actively engaged in sifting through new information about the Soviet Space Programme that has become available with the ending of the Cold War and searching out more, he writes exclusively for *Spaceflight* on the current progress of his research based on a lecture presentation to the British Interplanetary Society at its Symposium on 'Soviet/CIS Astronautics' on 3 June 1995.

The Baikonur Museum director hugged me in gratitude for making these changes possible. In 1990, there had been only a small, unlabelled glass-covered case in a poorly-lit back corner, holding a charred notebook and a few books about Nedelin. In 1995, there were two full-size wall-mounted cases in the main entrance hall, with the same charred notebook, but also with explicit labels about the 1960 accident, with photographs of the missile which exploded, with fragments of the missile, and with a plaque listing the "Testers of Baikonur" who perished. That list is similar to the one that I saw in 1990 on the obelisk in the memorial park in Leninsk, but it is not identical. There are several spelling errors and Nedelin's name is on the museum's list.

It was explained to me that these names are only of those victims who were from the Baikonur contingent, and that the ICBM engineers and technicians on temporary duty from the Yangel Bureau in Dnepropetrovsk are not listed. More than fifty names are given on the Baikonur list, but the best estimates of the total death toll now centre around 165 fatalities.

Lt. Col. Nechyosa, the cosmodrome historian, told me that it was the publication of my articles on the "Nedelin Catastrophe" (mainly the one in *Air & Space* in December 1990, which was later translated for the Russian newspaper *Sovershenno Sekretno*) that allowed him to persuade his commanders to authorize a full, accurate account of the 1960 disaster in the official museum. Progress is now slow but steady. He is still working on an exhibit detailing the N1 moon rocket.

Such activities by in-country Russian historians "close the loop" in our persistent historical pursuits, where our private efforts have prompted the Russians to go even farther and deeper than we ever could from afar. It is a marvellous, deeply rewarding development. And it turns out that they knew of our work for decades. It encouraged them that serious researchers wanted the real story, and thus many

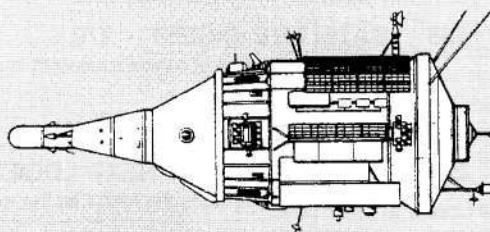
BY JAMES OBERG

Texas, USA

of them secretly stashed historical materials in safe storage, awaiting the day when it could all come out and be shared. That day has come.

The last few months have seen more major new releases of Soviet space history data. Most impressive were the photographs in the Energiya Bureau's booklet, "From the First Sputnik to Energiya-Buran and Mir". The historical insights - and new questions - were recently detailed in my letter published in the May issue of *Spaceflight*. Stunning pictures of the N1, of the Zenit military spy satellites, and of other vehicles offered completely new insights into those projects.

The flood of anecdotal and personal experiences has also continued, and I want to take this opportunity to share



A drawing of the TKS (Transportnaya Korabl Snabscheniya) system for resupplying Almaz military space stations with crew and cargo. MICHAEL NAGEL

many of the tidbits with my associates. They may in turn be able to place the clues into hitherto-unperceived patterns with seemingly-unrelated other clues. It has always been so in this long-term, but satisfyingly successful, sleuthing activity.

At the Energiya Museum in Kaliningrad, which I visited last March, I enjoyed seeing my book *Red Star in Orbit* on display along with Nick Johnson's reports and other Western items. But I also enjoyed seeing and, for the first time, understanding some open questions, such as the bizarre seating arrangement inside Voskhod and Voskhod-2, and the landing retro-rocket mounted on the Voskhod shroud lines, and the Voskhod nose-mounted deorbit propulsion package.

(The tour guide insisted it was the only deorbit rocket on Voskhod, and that there was nothing else in the aft service module). Until my visit and my view of the new Energiya book, I had been unaware of the boom-mounted solar-panel 'fan' on the nose of Vostok-1.

Behind the Vostok-1, in a draped corner, I spotted the "mystery white sphere", a 150 cm half-charred object which I had never seen the like of before. The tour guide said it was called "Zenit" (but not the same as the photo-reconnaissance vehicle), that it was orbited just once, in 1967, and that it was a communications relay test payload. Hmmm, that just does not add up. I was able to get some brief time alone with it, removed the top cover, and got a few "in the blind" photos of the interior. Also, I inspected the surface and found it to be metal, not ablative. So far, in discussions with associates, I have ruled out Vostok/Zenit, Mars/Venera small lander, Mars/Venera large lander aeroshell, FOBS/Express, and Luna return capsule, but I am still wondering if it might have been a Vertikal component. I would appreciate any suggestions.

In another hall of the museum I spotted an unlabelled model of what looked like a two-stage Proton with launch escape system, out of place since it was made by the Khrunichev group, not by Energiya. This might well be the manned TKS system for resupplying the Almaz military space stations, but even if so, what is it doing in the Energiya Museum? The guide did not know.

The validity of detecting spacecraft anomalies from museum exhibits has long been known, and the best earlier example I can think of is the one from 1989 when I spotted (and photographed) a Salyut-5 stylized drawing on a plaque in the Star City museum. As the photographs I took show, the artist's concept is strikingly similar to the later-released drawings of Salyut-3 and -5. It is interesting to point out that the Salyut-5 plaque in question is no longer on display in Star City.

Here is another story. During a luncheon which I arranged last October to allow retired US spacecraft designer Max Faget to meet Vladimir Titov and Gennadiy Strekalov, the cosmonauts whose lives were saved by the Soyuz launch escape tower in 1983 (a system that Faget invented for Mercury, and which the Russians subsequently copied), the space veterans swapped stories about launch escape towers. Strekalov related an unfamiliar tale of an unmanned test launch of a manned spacecraft - Soyuz or Zond, it was not clear - in which a long pad delay was caused by some systems problem. After about forty minutes, without any warning, the launch tower suddenly fired and pulled the capsule

into the sky. It turned out that the escape system is triggered automatically by sensing a course deviation of ten degrees. The autopilot reached that limit due to the Earth's rotation, then decided the spacecraft was falling over, and therefore commanded the abort. I would like to figure out what launch attempt he was talking about.

An illustration of how supportive the Russians can be to Western history researchers is the mystery train track of pre-World-War-II Tyura-Tam. German military intelligence maps dated 1939 show a track laid northwards from the Tyura-Tam station. I distributed copies to our hosts at Baikonur and they were fascinated by it, later making their own inquiries in their own time. They all agreed it was an excellent map - even a lone hill plainly marked on the old map is still there and the main road and railroad actually have to be diverted around it. By the second day of my visit they were able to point out the remains of the old train bed as it diverged from the main Leninsk-Baikonur road at the far north end near the cosmodrome, and they explained that they had found out it had been built by a British mining firm in the 1930s, which had been looking for iron ore. I am still not fully satisfied with that account, since the 1930s was the time when the entire region was covered with gulag slave labour camps, and this could have been one, as well. Also, all former official histories of the cosmodrome state that the work was started 'from scratch' in 1955 and, now we know that is not true, we can expect to find out more from local historians who have become excited by the old maps. I left lots of copies.

As we push into the last dark corners of Soviet "space secrets", the dwindling list of unknowns needs constant revision so we can focus efforts and direct specific investigations. Old lists get satisfied item-by-item, and become obsolete. Here is the way my current list goes:

Polyus

This Energiya-1 payload has a lot of mystery surrounding it, especially its connection with the Soviet space-based laser/beam weapon programme. Some partial cover stories have come out in recent years, but I remain unsatisfied with the degree of openness on this hundred-ton object. Also: what was the intended orbital inclination, 52 or 65 degrees?

Kosmos-382, the Proton-launched man-related payload in 1970

Since the Kosmos-379 series is now well understood, what is holding up full disclosure on this vehicle and on its possible related launch failure in November 1969? And along those lines, let us not forget Proton-4: why was it launched in late 1968 to check out the Earth orbital three-stage version of a booster that was not known to have any other mission. (Salyut was not approved until early 1969)? Why indeed?



The special panel at the Baikonur Museum that commemorates the "Nedelin Catastrophe" of 24 October 1960. Photo: THEO PIRARD

Salyut-2/Kosmos-557 simultaneous manning in April-May 1973

Yes, I know the Russians say that a single manned flight required the total dedication of their entire civilian and military communications networks, but why launch two different types of manned space stations within a few weeks of each other? Was it another super-stunt that backfired?

Chelomey's manned lunar spacecraft of the early 1960s

What was its configuration, the mission profile, and details of any flight tests planned or attempted? Sergey Khrushchev's memoirs are wordy and interesting for their own reasons, but so far are unhelpful for these details.

How close did anyone ever come to stowing away aboard a Progress, or an add-on module?

Stories abound of workers at Baikonur attempting to rig equipment and sneak into the cargo hold for a launch into orbit. Did anyone ever get out to the pad?

Chelomey's "killer-satellite" and its relation to Polyot (1963-4)

I make a note to get pictures, memoirs, details on tests of ground-based anti-satellite systems, from ABM missiles to high energy weapons.

The Znamya space mirror

I also make a note to get good photos of the deployment, follow-on plans. Also, other plans for deploying innovative payloads such as the Rapunzel space tether.

The early payloads of the Zenit booster (the so-called "hulks") in the late 1980s

What were they really, why was one sent into a sun-synchronous retrograde orbit with no follow-on? And what was that debris that wound up flung into a higher orbit at insertion and which, on the first launch, were the only objects to reach orbit (the Soviet failure to register them with the UN was their most egregious violation of the Convention on Registration of Outer Space Objects).

Jettisoned old spacesuit on an early Mir EVA

There is a wonderful story with cosmonauts saluting the "fallen comrade" as "he" drifts away. When did this happen, and are there pictures?

Other questions

Were there any unknown orbital launch attempts from secondary programmes, military or otherwise? Were there manned suborbital missions from Kapustin Yar in the 1958-1960 period. (I would bet against it, but the book is not entirely closed)? Did the Soviet military recover any lost Discoverer capsules? What other US-origin space debris have they found, studied, and preserved? Did they ever have to go outside their own country - say, into Iran or China - to retrieve errant space objects? And what about that reported late-1960s Soyuz-class vehicle on display in the People's Army Museum in Beijing? What are their best, favourite photographs of Baikonur Cosmodrome from orbit? Where are sample photographs from the Salyut-3/5 military reconnaissance cameras?

In conclusion, while this wealth of information continues to flow and be assessed, I want to suggest that a sense of urgency be maintained. This is no time to relax, to coast. This new window of opportunity still remains open, and we have valuable new allies within Russia, but there is no guarantee that new changes do not await us that will undo much of what has been gained. As years pass, memories fade and eyewitnesses die, and hardware and documents degrade or are lost entirely. As historical material assumes commercial value, we have seen prices soar. As space hardware becomes a subject for international trade, we have seen honesty fade away. As political winds shift, access to other archives has weakened. Our task remains important, our work remains difficult but rewarding. ■

Lifting the Veil

US - Soviet Competition and Cooperation in Space Prior to Apollo

The United States government is currently in the process of declassifying many Cold War records. Despite an excruciatingly slow pace, several interesting and informative documents have emerged in recent months which shed new light on the early years of the space age. Recently declassified CIA estimates of the Soviet space programme in the late 1950s reveal what the United States knew about what its rival was doing.

Similarly interesting are new NASA documents which reveal that a co-operative lunar exploration programme with the Soviet Union was being discussed within the government before Kennedy decided that the US should pursue this goal on its own.

The Central Intelligence Agency's Office of National Estimates initiated a series of "National Intelligence Estimates," or NIE's, beginning on 13 November 1950. Although the machinery for producing these documents was housed within the CIA, they were actually the result of collected intelligence from the entire US Intelligence Community*.

NIE's were generally regarded as the highest and most important form of finished intelligence analysis produced by the Intelligence Community and often carried a classification of "Top Secret."

Initial Estimates of the Soviet Space Programme

The 1958 NIE "Soviet Capabilities in Guided Missiles and Space Vehicles," dated 19 August 1958, is particularly interesting. Sections I-III address air defence, air to surface, and surface to surface missile systems, respectively. Section IV addressed the Soviet space programme and opened by noting that the programme should not be regarded as serving a clear military need, although technology developed for such a programme could have military implications. It further stated,

"We believe that the ultimate foreseeable objective of the Soviet space program is the attainment of manned space travel on an interplanetary scale. At present the program appears to be directed toward the collection of scientific data which would be applicable to Soviet space activities, ICBM program and basic scientific research. While the Soviet space program was undoubtedly initiated to serve scientific purposes, an immediate aim was to achieve political and propaganda gain. Soviet Earth satellite launchings to date have ostensibly been in support of the IGY, although

* The Intelligence Community consists of the CIA, the Federal Bureau of Investigation (FBI), the National Security Agency (NSA), the State Department's Bureau of Intelligence and Research (INR), the Department of Energy (DOE - originally known as the Atomic Energy Commission), the intelligence arms of the military services, and the Defense Intelligence Agency (DIA).

BY DWAYNE A. DAY

Space Policy Institute
The George Washington University

the USSR has revealed almost no significant data to the West."

The report further stated,

"There is no direct evidence on the priority assigned to the Soviet space program. From the launchings of the Sputniks, from statements by Soviet scientists and high government officials and from the fact that hardware was diverted from the high priority missile program, we believe the inference can be drawn that the Soviet space programs and military missile programs are complementary."

The report included an overview of a possible Soviet space development programme (in Table 6 of its Annex A). This table presented various possible objectives and the earliest date by which they could be accomplished. Manned circumlunar flight was believed to be feasible in 1961-62. Manned lunar landings were believed to be possible "after 1965."

What is interesting to note about this information is that it was also incorporated into a high-level Eisenhower administration policy document, NSC 5814/1. This document, a statement of Eisenhower Administration space policy produced before a civilian space agency had begun operating, was prepared under National Security Council auspices. The document, NSC 5814, was sent to the National Security Council on 20 June 1958 for discussion even though disagreements remained on some aspects of the statement of US objectives in space and of the policy guidance for US space activities. After substantial revisions, in particular to meet the objections of Chairman of the Joint Chiefs of Staff Nathan F. Twining, the document finally emerged as NSC 5814/1 on 18 August 1958. NSC 5814 and NSC 5814/1 were both declassified in December 1981.

The timetable for various possible objectives in space was included in



First image successfully returned from space, taken by a CIA satellite, Discoverer 13, under the code-name CORONA. This image shows a military airfield near Mys Schmidt on the Chukchi Sea in far northeastern Russia. Such satellite images provided a wealth of information on the Soviet space programme, filling in many of the unknown details in National Intelligence Estimates produced in the 1960s.

Photo courtesy NATIONAL RECONNAISSANCE OFFICE

the final version of the document along with potential dates for US achievement of the same objectives. The information on Soviet timetables was said to have been provided by "the Guided Missiles Intelligence Committee (GMIC) of the IAC as of June 3 1958." The IAC referred to the Intelligence Advisory Committee, but it was essentially a term for the Intelligence Community. This information is presented separately as Table 1.

When this policy document was prepared, Eisenhower made a conscious decision not to enter into a "race" with the Soviet Union in space. Despite the fact that the United States was capable of beating the Soviets in many key areas, Eisenhower did not give approval for a space race with the Soviets, particularly a race to the Moon.

Early Assessments of the Soviet Unmanned Lunar Programme

The 1959 NIE, dated 3 November 1959, stated that the USSR had announced that the objective of its programme was the attainment of manned interplanetary travel. It also concluded that the Soviet space programme had four main objectives: manned space travel; scientific research; propaganda; and military applications.

The report noted the recent Lunik lunar probes (now referred to as Luna 1, 2, and 3). Luna 2 was the first man-made object to impact another body. It was launched on 12 September 1959. Luna 3, launched on 4 October 1959, was intended to photograph the far side of the Moon. The report stated,

"During the transit of the Lunik beneath and beyond the moon - not around the moon - there was a change in the

modulation on 183.6 mc/s that could indicate the transmission of photographic data to the Soviets. Lunik III became an Earth satellite with an approximate 16-day orbit. The Soviets have triggered the primary data link only when the information can best be received in the USSR, thereby preventing the West from intercepting an appreciable amount of data or locating the vehicle."

The report further outlined many potential scientific and military space missions and concluded by addressing "probable next steps" in the Soviet space programme. It stated that within the next twelve months the Soviets could be expected to attempt one or more of the following: vertical or downrange flight and recovery of a manned capsule; an unmanned lunar satellite or soft landing on the moon; a probe to the vicinity of Mars or Venus; and orbiting and recovery of capsules containing instruments, an animal, and thereafter perhaps a man.

The report also included a revised table listing a "possible Soviet space development program." Several of the dates for various objectives had slipped from the 1958 report. Manned circumlunar flight had slipped from 1961-62 to 1964-65. Temporary manned lunar satellites were believed possible in 1965-1966. Lunar landings, previously believed possible "after 1965," had now slipped to "about 1970."

Early Estimates of the Soviet Military Space Programme

On 3 May 1960, the Office of National Estimates produced another estimate, NIE 11-5-60. Following the previous report by only five months, this NIE was intended primarily to supplement the earlier report with its data replacing information in the earlier report. It is considerably smaller.

The space section of the report occupies less than a third of a page (compared to the seven pages of the earlier report). It stated that the Soviet space programme had achieved a significant number of firsts and demonstrated a high degree of technical competence, capitalising on Soviet advances in powerful rockets, but it qualified this by stating,

"Nevertheless, the number of launchings to date has been less than we previously expected, and the Soviets do not seem to have followed a systematic program designed to achieve maximum progress toward clearly-defined scientific goals."

One interesting revelation in the report is the first estimate of when the Soviets would be capable of various military space missions. A policy document based upon the same intelligence data titled "US Policy on Outer Space," and dated 26 January 1960, had been declassified in 1981. This document, which was originally circulated as NSC 5918, but later issued as

EARLIEST POSSIBLE TIME PERIODS OF VARIOUS SOVIET AND U. S. ACCOMPLISHMENTS IN OUTER SPACE

(NOTE: Generally, Soviet vehicles will be of substantially greater orbital payloads than U. S. vehicles. It should be noted, however, that the comparative capabilities of the United States and the USSR should not be measured by orbital payloads alone. The United States is estimated to be considerably ahead of the USSR in miniaturization of missile and satellite components, and therefore the effectiveness of U. S. satellites on a "per pound in orbit" basis is estimated to be greater than that of the USSR.)

	<u>SOVIET^{a/}</u>	<u>U. S.^{b/}</u>
1. Scientific Earth Satellites (IGY Commitment)	1957-58	1958
2. Reconnaissance Satellites ^{c/}	1958-59	1959-61
3. Recoverable Aeromedical Satellites	1958-59	1959
4. Exploratory Lunar Probes or Lunar Satellites	1958-59	1958-59
5. "Soft" Lunar Landing	1959-60	Early 1960
6. Communications Satellites	---	1959-60
7. Manned Recoverable Satellites		
a. Capsule-type Satellites	1959-60 ^{d/}	{ 1960-63
b. Glide-type Vehicles	1960-61	
8. Mars Probe	Aug. 1958 ^{e/}	Oct. 1960
9. Venus Probe	June 1959 ^{e/}	Jan. 1961
10. 25,000-pound Satellite -- manned	1961-62	After 1965
11. Manned Circumlunar Flight	1961-62	1962-64
12. Manned Lunar Landing	After 1965	1968

a/ Estimate by the Guided Missile Intelligence Committee (GMIC) of the IAC as of June 3, 1958.

b/ Source: Department of Defense, June 4, 1958.

c/ Defense Commitment: (See Annex B for test reconnaissance satellites.)

The United States plans to launch a reconnaissance satellite of approximately 3,000 pounds in late 1959. During the same time period the USSR is estimated to be capable of launching a 4-5,000 pound reconnaissance satellite.

d/ The Joint Staff member of GMIC reserves his position on the date 1959.

e/ The Soviets most likely would attempt probes when Venus and Mars are in their most favorable conjunction with the earth for such an undertaking.

NSC 5814/1

- 13 -

SECRET

Table 1: A page from National Security Council document NSC 5814 which was prepared in 1958 before a civilian space agency came into operation.

a National Aeronautics and Space Council document, contained a table identical to that included in the NIE, but with a portion under the category "military satellites" excised. These figures can now be obtained from the declassified NIE.

The estimate was that four different types of military satellites would all be within Soviet grasp by 1960. These were: surveillance (weather, mapping, and force deployment); navigation, geodesy, and communications; early warning; and ECM (electronic countermeasures) and Elint (electronic intelligence). In actuality, the Soviets did not achieve any of these categories until more than a year later. It can be surmised that this portion was deleted from the policy document in 1981 more for what it said about the US military space programme than the Soviet one, since the US military pursued the same military space missions as the Soviets.

The report concluded by repeating the same possible future achievements by the Soviets within the next year as seen in the 1959 NIE. In this, the report proved reasonably accurate. Although several Soviet Mars and Venus attempts in late 1960 and early

1961 met with failure, the Soviets skipped the manned ballistic spacecraft approach used by the US for the initial part of the Mercury program and launched Yuri Gagarin into orbit less than a year later.

Cooperation with the Soviets in Lunar Exploration Prior to Apollo

Unrelated to the declassification of the NIE's, several new documents have been declassified by NASA which shed new light on a previously unknown proposal for space cooperation with the Soviet Union in the early months of the Kennedy administration. These documents alter somewhat our understanding of the atmosphere surrounding Kennedy's lunar decision.

Previously it was known that Kennedy made a public overture to the Soviets long after he had made the lunar decision, offering to make the effort a cooperative one. This overture, made in an address before the UN General Assembly on 20 September 1963, was interpreted by some as an indication that Kennedy was having second thoughts about the decision. Having served its purpose of solving an initial public relations crisis in the wake of both Gagarin's flight

and the Bay of Pigs, the Apollo decision was now becoming a costly liability. But these newly released documents offer the possibility of changing that perception somewhat, since they indicate that cooperation with the Soviets on various space efforts, including manned lunar flight, was being actively discussed within NASA and other branches of the US government before Gagarin's flight.

Beginning apparently in March 1961, a study group was formed within NASA to address the issue of US-Soviet space cooperation. By 29 March 1961, the group had developed a draft proposal which stated that its objective was,

"To contribute to reduction of cold war tensions by demonstrating the possibility of cooperative enterprise between the US and the USSR in a field of major public concern. Such cooperation should be proposed and carried out without prejudice to an expanding program of joint enterprise with and assistance to the free world."

The document was five pages long and classified "Confidential" - the lowest possible security classification.

On 3 April 1961, Philip J. Parley, who was Special Assistant to the Secretary of State for Atomic Energy and Outer Space, sent a memorandum to David Beckler, Assistant to the Special Assistant for Science and Technology at the White House, and Arnold W. Frutkin, Director of the Office of International Programs at NASA. Parley referred to a 30 March meeting with Jerome Wiesner, President Kennedy's Science Advisor. Eugene B. Skolnikoff apparently was either at the meeting or reviewed the draft. Parley's letter included a redraft of the earlier document, incorporating comments made by himself and Skolnikoff. These essentially put the proposal into a more coherent form. This redraft was also labelled "Confidential" and was nine pages long. The document was rewritten a second time, incorporating several changes and dated 4 April 1961.

The final revision contained numerous minor, but telling, differences from the original. The proposal was no longer solely to reduce cold war tensions, but to,

"Confirm concretely the US preference for a cooperative rather than a competitive approach to space exploration."

Furthermore, such cooperation was,

"To achieve the substantive advantages of cooperation that in major projects would impose more of a strain on economic and manpower resources if carried out unilaterally."

The proposals fell into three categories:

- A The employment of existing or easily attainable ground facilities for exchange of information and services in support of orbiting experiments;
- B The coordination of independently-

launched satellite experiments so as to achieve simultaneous but complementary coverage of agreed phenomena;

- C Coordination of or cooperation in ambitious projects for the manned exploration of the Moon and the unmanned exploration of the planets.

The goal was not to be seen as "pushing" a pre-selected objective. Category A was considered to be the least expensive and least risky of the proposals, whereas Category C had an estimated price tag of \$10 billion.

Category A could have included ground-based support for magnetometer experiments, meteorological satellite calibration, other scientific experiments related to ionospheric or geophysical research, telemetry calibration, and communications experiments. The latter could be conducted in concert with France or the United Kingdom. Category B proposals centred primarily on meteorology, including the possibility of a joint weather satellite system. Category C proposals included Mars or Venus programmes (the first version of the document noted that the US, unlike the Soviet Union, lacked a capability to launch an unmanned Mars probe), or manned exploration of the Moon. In this regard the document stated:

"The presence of man will immeasurably enhance the scientific investigation of the moon - so critical for understanding the origin of the solar system - by providing the resourcefulness, flexibility and opportunity for improvisation available only with man.

As a first step in non-limited cooperative effort, the US and the USSR would each undertake to place a small party (about 3) of men on the moon for scientific purposes and return them to earth.

As in planetary programs, a more extensive cooperative program could also be envisaged in which the US and USSR enter into a joint manned lunar program, including cooperative development, planning, and international exploration.

The proposals made in Category C, in the lunar and planetary fields, suggest programs for which the USSR has demonstrably greater existing capability. Inclusion of both categories in proposals to the USSR may therefore be effective."

The document also noted the potential dangers of such cooperation, including the high costs of a vigorous programme as well as the potential damage that would result if the Soviets withdrew. This would make Congressional, scientific and public sup-

National Intelligence Estimates (NIE)

Beginning in 1954, the CIA issued an NIE focused on Soviet missile capabilities called "Soviet Capabilities and Probable Programs in the Guided Missile Field," (NIE 11-6-54, 5 October 1954). The second report in this series was produced on 12 March 1957 (NIE 11-5-57). The third report in this series, issued on 19 August 1958, had a name change to "Soviet Capabilities in Guided Missiles and Space Vehicles" (NIE 11-5-58, a special "Memorandum to Holders" was issued on 25 November 1958 and given the designation MH NIE 11-5-58). This report also included assessments of Soviet capabilities in various space endeavours. The fact that space was not included in previous NIE's indicates the low value placed on the issue by the intelligence community before the Soviets launched a satellite. On 8 September 1959, the fourth report in the series was released in advance (NIE 11-5-59). The full report was not printed until 3 November, 1960 (NIE 11-5-59). The fifth and final report was dated 3 May 1960.

The May 1960 document appears to have been the last report to address the guided missiles and space subjects collectively. After this time, ballistic missiles were addressed in a separate series titled "Soviet Capabilities for Long Range Attack" (initially "Soviet Capabilities for Long Range Attack Through Mid-1965") and later "Soviet Capabilities for Strategic Attack." Air defence and other guided missiles were addressed in another series "Soviet Strategic Air and Missile Defences" (initially "Sino-Soviet Air Defence Capabilities Through Mid-1966"). Space programs were addressed in their own separate series "The Soviet Space Program." It is not clear whether this series was begun in 1961 or 1962. Only two docu-

ments from this series have been declassified: NIE 11-1-62, dated 5 December 1962, and NIE 11-1-67, dated 2 March 1967. In addition, one other NIE relating to Soviet space capabilities was recently declassified. This is NIE 11-9-63, "Soviet Capabilities and Intentions to Orbit Nuclear Weapons," dated 15 July, 1963. It concluded that the disadvantages of orbiting nuclear weapons - primarily their high cost and limited effectiveness - outweighed the advantages, although it did not rule out the possibility. Fortunately, this never happened.

Over 340 NIE's and their predecessors, known as ORE's, have been declassified and made available to the public at the National Archives and Records Administration in Washington, DC. All pertain to the Soviet Union and have been released in several batches. The most recent batch, dealing primarily with Soviet Strategic Forces Estimates, was only made available to researchers in February 1995 - approximately nine months later than expected. This batch included the second through fifth issues of the guided missiles reports as well as the advance issue of the fourth report and the special "Memorandum to Holders." The documents contain only minor deletions known as "redactions." These are primarily related to sources of intelligence data. At the time, most hard evidence on the Soviet space and missile programme came from highly provocative (and still largely secret) U-2 overflights of Soviet territory as well as monitoring of tests and electronic emissions from ground stations in Turkey. Rather surprisingly, the only non-source information that appears to have been redacted is estimates of the yields of Soviet nuclear weapons.

port more difficult. Also, included parenthetically, was the possibility that such cooperative efforts could be pursued under the auspices of the United Nations.

As it was, events outpaced the proposals set forth by the NASA team. Only a week later, on 12 April, Yuri Gagarin orbited the Earth. Two days after that Kennedy held the first discussion of a potential response. On 19 April he discussed the issue with Vice President Lyndon Johnson and ordered him to look at possible responses to the Soviet action. Johnson replied a little over a week later and on 25 May 1961, before a joint session of Congress, Kennedy stated his decision to send Americans to the Moon.

But the study group effort begun in March 1961 did not die out. It apparently continued, including members from other agencies as well as the State Department. On 20 February 1962, Soviet Premier Nikita Khrushchev congratulated Kennedy on John Glenn's orbital flight, and proposed a cooperative space effort. On 7 March, Kennedy replied to Khrushchev in a letter and suggested cooperation in five fields: creating a world weather satellite system; exchanging tracking services; mapping the Earth's magnetic field; investigating the potential of satellite communications; and exchanging data on space medicine. Kennedy also mentioned cooperative robotic lunar exploration and joint efforts to define requirements for Venus and Mars exploration. This initial dialogue later led to meetings between NASA Deputy Administrator Hugh Dryden and Academician Anatoli A. Blagonravov of the Soviet Academy of Sciences. On 8 June 1962, they concluded a weather satellite agreement which called for

cooperative meteorology efforts between the two countries in two stages. This agreement was announced before the United Nations in December of that year.

Conclusions

What is also fascinating about the documents, besides the fact that they show that there were discussions of a cooperative lunar mission before Kennedy chose a competitive path, is that they also give a good impression of NASA biases and assumptions before Kennedy made his decision. For instance, the initial document stated that the proposals in Category C were likely to be pursued by the Soviet Union regardless of any cooperative effort. By the 4 April document, the words "or ourselves" were included after the reference to the Soviet Union. On 4 April this was rather wishful thinking on NASA's part, given the fact that Kennedy had turned down a NASA request to begin the Apollo program earlier in March. Three weeks later, the possibility of the United States undertaking a manned lunar goal was not nearly so remote.

Similarly, the first two versions of the document outline how NASA thought a lunar mission would be undertaken,

"It will require boosters of the order of Saturn C-2 using orbital rendezvous and refuelling techniques for the upper stages. At least six Saturn C-2's would be required for a single mission, plus appropriate back-up. The time-scale is probably a decade, during which some 70-80 Saturns would be required for developmental purposes, and the cost is roughly of the order of \$10 billion. During the decade, alternative vehicle systems may conceivably become available, obviating the difficult rendezvous



President Kennedy delivers his historic message to a joint session of the Congress on 25 May 1961 that committed the United States to a manned lunar programme. Released documents now show that there were discussions with the Soviets for a cooperative lunar mission before Kennedy chose to take a competitive path.

NASA

requirement."

The \$10 billion figure was consistent with other NASA estimates of the lunar goal at the time. After Kennedy had committed to the lunar decision, NASA Administrator James Webb doubled the cost to \$20 billion and proved remarkably accurate in this estimate.

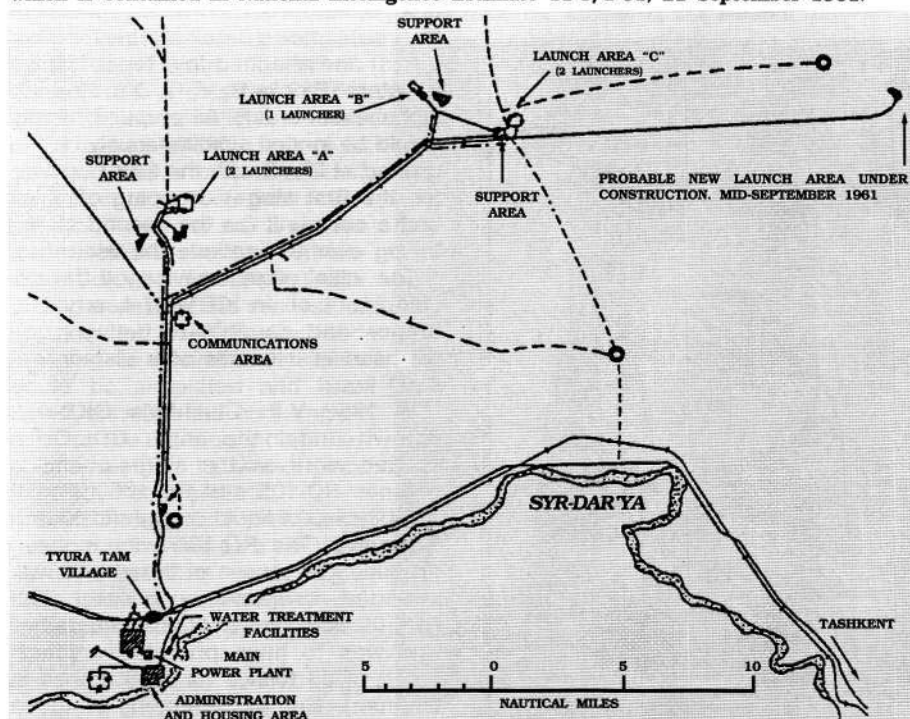
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These documents demonstrate that there were initially low-level discussions of space cooperation with the Soviet Union from the earliest days of the Kennedy Administration, but that they became side-tracked somewhat by events, only to be returned to later.

Who were the key individuals involved in these discussions and how did they later progress? Was there any discussion of these proposals during Johnson's meetings between 20-28 April, 1961? These questions await further declassification of documents. One of the obvious questions that arises is why such important documents, classified at the lowest possible level, took almost 34 years to emerge from NASA's archives. Most of the explanation lies with the personal agenda of one of the participants.

Although in the United States it is actually illegal to classify documents for political purposes, once documents are classified for legitimate national security reasons those who have a say over their declassification have a broad degree of latitude in preventing their release to the public at large. Thus it was possible for one high-ranking NASA official to prevent these documents from being declassified long after they would have had any effect upon national security. Unfortunately, even with the greater openness in the United States government as a result of the end of the Cold War, it is still possible for such abuses to occur. ■

An extract from the CIA map of Tyuratam Missile Test Center in late 1960/early 1961 which is contained in National Intelligence Estimate 11-8/1-61, 21 September 1961.



Soviet Rocketry that Conquered Space

Part 1: From First ICBM to Sputnik Launcher

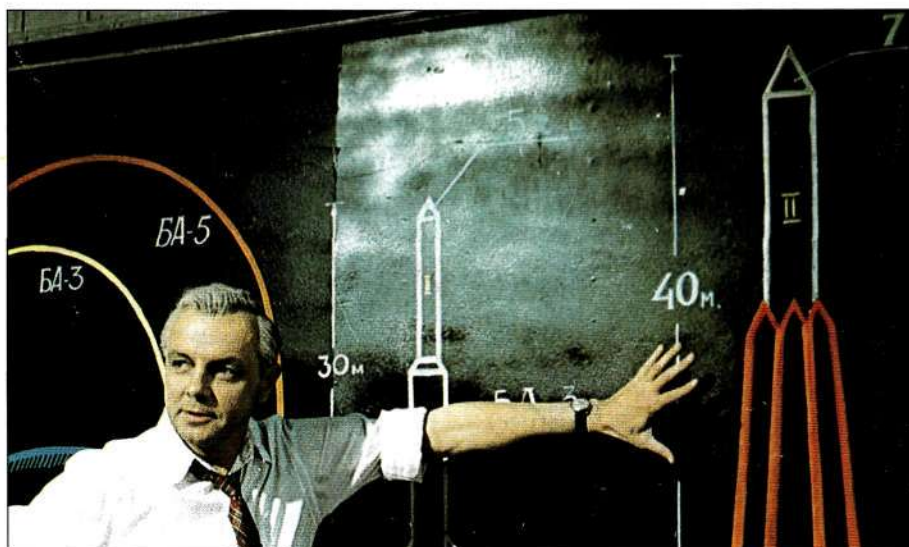
It is widely known that the Soviets disclosed very little information about their space programmes. It is only in the last years that something has appeared on the subject, but many projects remain undisclosed. Korolyov's R-7 ICBM went through a long evolutionary series of three and four-stage versions that were used for lunar and interplanetary programmes.

Detailed information about this work can now be presented by Timothy Varfolomeyev with drawings of launch vehicles by Alexander Shlyadinsky. In this issue of *Spaceflight*, the story is taken as far as the Sputnik launcher and will be continued in a forthcoming issue.

The Origin of the Soviet ICBM Programme

In the middle of 1947 a concept of *unitised* ballistic missiles was proposed by M.K. Tikhonravov [1] who was one of the Soviet Union's rocketry pioneers. After WWII he worked at NII-4 of the Defence Department of the USSR (NII in Russian stands for Nauchno-Issledovatel'skiy Institut or in English for Scientific Research Institute). The Institute which was designated "military command 25840" [2] was in the Academy of Ordnance Sciences at that time.

Tikhonravov's "rocket packet", as he called it, was conceived as a cluster of identical rockets which would



Birth of the R-7 ICBM concept. A still from the Soviet fiction movie "Taming of Fire".

FILM STUDIO "MOSFILM" (1973)

BY TIMOTHY VARFOLOMEYEV

St Petersburg, Russia

be jettisoned during the ascent when their propellants had been used up. S.P. Korolyov was acquainted with this suggestion.

During 1949-1951 the Mathematical Institute of the Academy of Sciences (MIAN is its Russian acronym) of the USSR conducted feasibility studies on various schemes for viable multi-stage ICBM configurations under Korolyov's orders. Many versions of the "rocket

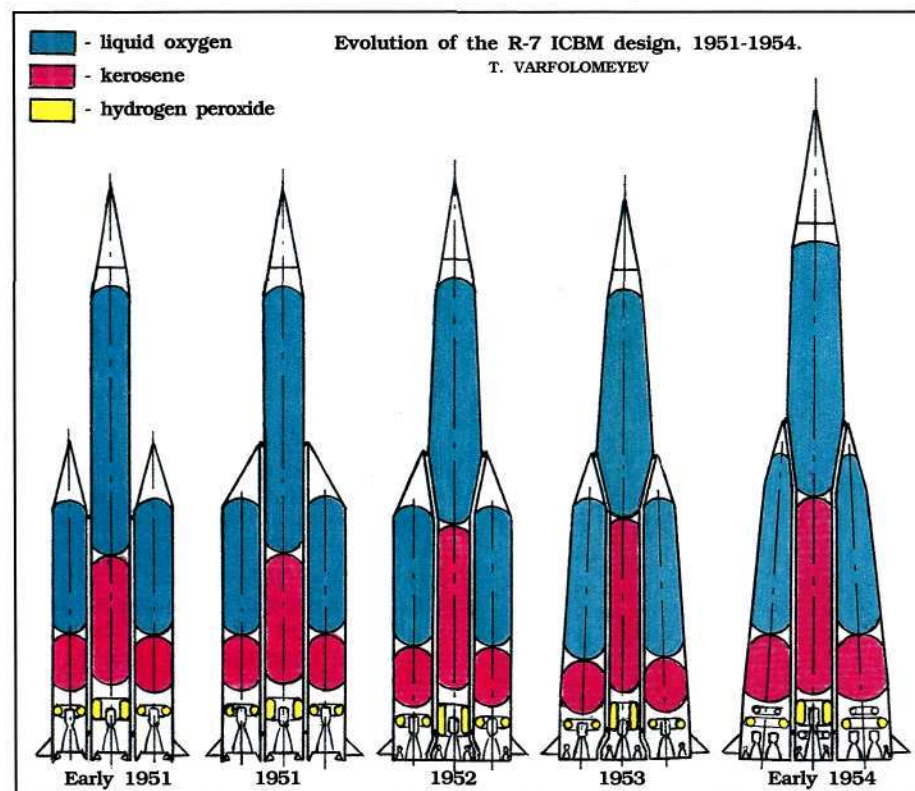
packets" were examined, namely: "nourishable" (feeding) packets with propellants pouring from tank into tank, those consisting of separate integral tanks without pouring, those of three, five or seven identical rockets and those of rocket units of different sizes and loaded fuel weight [3].

In December 1950 Korolyov's OKB-1 (OKB in Russian stands for Osoboye Konstruktorskoye Buro or in English for Special Design Bureau) began work on determining the performance characteristics of missiles with long range capability in the quest for an optimal design of ICBM [4].

In 1952 common NII-4/MIAN/OKB-1 efforts went into the design of a five-unit packet missile consisting of a central sustainer (Block A in Russian terms) and attached to it four strap-on boosters (Blocks B, V, G, D in Russian alphabetical order). All propulsion units would be ignited simultaneously on the ground at lift-off with the four boosters (as the first stage) dropping off later and a core unit (as the second stage) taking over to continue the ascent.

The initial project envisaged the development of an ICBM of nearly 200 tonnes and capable of delivering a warhead of 3 tonnes at a distance of 8500 km.

In 1952 V.P. Glushko's OKB-456 (known under the name GDL-OKB) started work on the single-chamber engines RD-105 and RD-106 using a combination of liquid oxygen (LOX) and kerosene. The RD-105 was to have produced 55 tonnes of thrust and was intended as a strap-on booster. The RD-106 was for a central sustainer and was to have provided a lift-off thrust of 53 tonnes (or 65.8 tonnes in vacuum). But development of these



powerful one-chamber LOX-kerosene motors came to grief due to serious problems with burning stability in the chamber.

Moreover in 1953 it became obvious that more powerful propulsion units would be needed to hoist a thermonuclear warhead that had turned out to be too massive.

Nevertheless through 1952 and 1953 the ICBM programme progressed on the definitive aspects of the design.

By the end of 1953 the final performance requirements were specified. The definitive design of the R-7 - the project stage designation given to the first ICBM - took shape and was approved in early 1954 [5].

8K71 - The First ICBM*

The R-7 would have been capable of transporting a warhead weighing nearly 5.4 tonnes across a distance of 8600 km. The loaded weight of the missile was to be 283 tonnes [6] and its propulsion units were to have produced nearly 400 tonnes of thrust at lift-off.

In 1953 OKB-456 worked out an outline design for the more powerful engines RD-107 and RD-108 and early in 1954 development and construction of the new motors began. Work on the RD-105/106 engines was then cancelled.

The RD-107 engine would have provided a lift off thrust of 83 tonnes [6] and would be attached to the bottom of each of the four strap-on boosters B, V, G and D. The RD-107 was designated "izdeliye" 8D74" during development and manufacturing stages. "Izdeliye" in English means "product". This name is given to any military and space production in Russia (and in the Soviet Union too). So Soviet/Russian designers, engineers, military men, managers and so on call missiles, rocket motors, launch vehicles and spacecraft by the same word - "izdeliye". The RD-108 ("izdeliye 8D75") which delivered a lift-off thrust of 75 tonnes [6] (95.5 tonnes in vacuum) was a propulsion unit for the core unit A. Both LOX-kerosene motors were similar four-chamber clusters. On account of the identical multi-chamber design, the process of construction, R&D testing and bringing to operational status could be simplified and hastened, although the core engine was to be a single-chamber one according to the original Korolyov requirements.

On 20 May 1954 the Soviet government came to a decision on the creation of an ICBM [5]. OKB-1 was given the go-ahead to begin development and con-

struction of the R-7 parts of the missile.

In July 1954 the R-7's outline design had been prepared in 15 volumes [7] and the first drawings had appeared of the missile components. The R-7 was given the development/manufacture designation "product 8K71".

In the middle of 1955 static firing tests with RD-107/108 experimental single combustion chambers were held. Then two chambers were clustered and in December 1955 static tests with a dual chamber assembly were accomplished. The four-chamber motor was static fired in January 1956 for the first time.

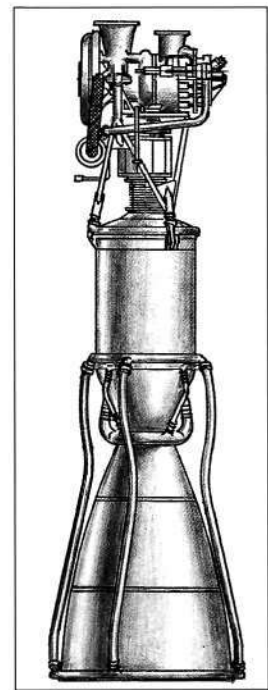
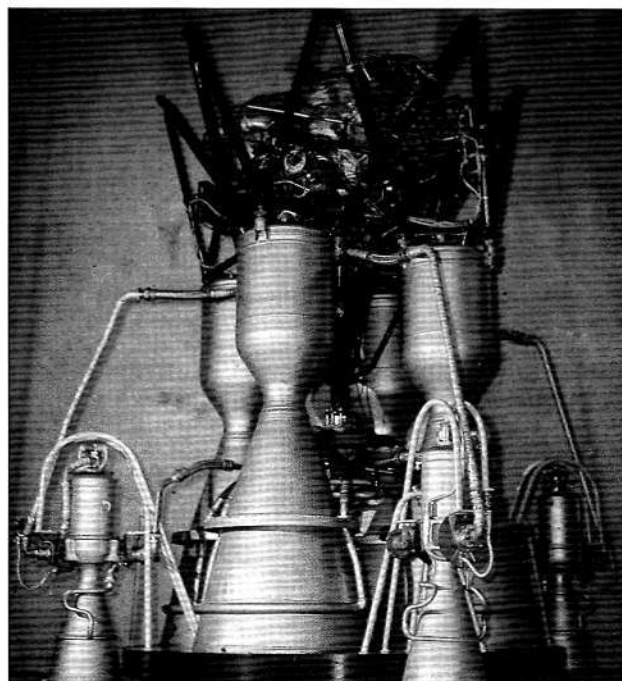
By the summer of 1956 the entire rocket unit was assembled (without boosters) - it included the central sustainer (Block A unit) - and in August 1956 was static fired for the first time at the huge test bench near Zagorsk (now Sergiyev-Posad) not far from Moscow [8]. Then the single booster was tested and finally all rocket units were put together and the total ICBM packet was tested in the winter of 1956-1957.

Meanwhile in December 1956 the first experimental model of the R-7, designated 8K71SN, was delivered at the Tyura-Tam Test Range [9] for installation on the launch pad and for captive tests.

In March 1957 the first R&D flight-ready version of the 8K71 ICBM arrived at Tyura-Tam for pre-launch testing and preparation [10].

The first three ICBM test shots - on 15 May, 9 June and 12 July 1957 - were failures. The next trial missile was fired on 21 August 1957 with moderate success. A mock-up of the warhead reached the specified range at Kamchatka but disintegrated into a

RD-108 - the engine of R-7's central sustainer. One can see that the actual development/manufacture designation, 8D75, and the serial number of the motor are sealed up by a strip of foil (near the bottom of the nozzles).



RD-105 (8D71) - the engine for strap-on boosters of an early version of the R-7 ICBM (1951-1953). This LOX-kerosene motor was to have provided a lift-off thrust of about 55 tonnes. A. SHLYADINSKY

few thousand pieces at an altitude of 10 km [11].

The 8K71's guidance and control system was developed and manufactured during 1954-1956. It was a combined system consisting of two parts - an autonomous inertial control system and a remote radioguidance system.

The missile's gyrodevices were developed by V.I. Kuznetsov's NII-10 and the radiosystem by M.S. Ryazansky's NII-885 [12]. Responsibility for inertial control system development and manufacturing was given to NII-4's design team headed by N.A. Pilyugin.

The inertial control system of the 8K71 ICBM keeps the missile on the desired trajectory ensuring angular stability in tilt and yaw and centre-of-gravity stability with the aid of systems for normal and lateral stabilisation and a system for adjusting the "apparent" velocity called the RKS system for short (RKS in Russian stands for *Regulirovaniye Kazhushcheisya Skorosti* or in English for Adjustment of Apparent Velocity) [6]. Shortly after lift-off two more subsystems were put into operation - there was (and there still is) a subsystem for the simultaneous consumption of oxidiser and fuel from the tanks, both for each booster and the central sustainer, and also a subsystem for synchronisation of the emptying rate of the tanks [13]. By means of a feedback circuit, the RKS system adjusted (i.e. throttled down or uprated) a single motor thrust or all of them together.

* Details of the Soviet Launch Vehicle Designation System will be given by the author in a forthcoming issue.

The 8K71's radiosystem had an important function. At 20-30 seconds before shut down of the core's engine 8D75, the motor went over to a final thrust stage - its main chambers would be cut off so that four small swivelling Vernier nozzles could take over and nudge the speed up to the required value. At this moment of change-over the RKS system would be switched off and the ground controllers would put into operation the radio-guidance system. As this system worked in conjunction with swivelling Vernier chambers, the controller could correct a lateral deviation of the second stage [6] and send out the command to finally cut off the core's 8D75 engine when the apparent velocity had reached the required value.

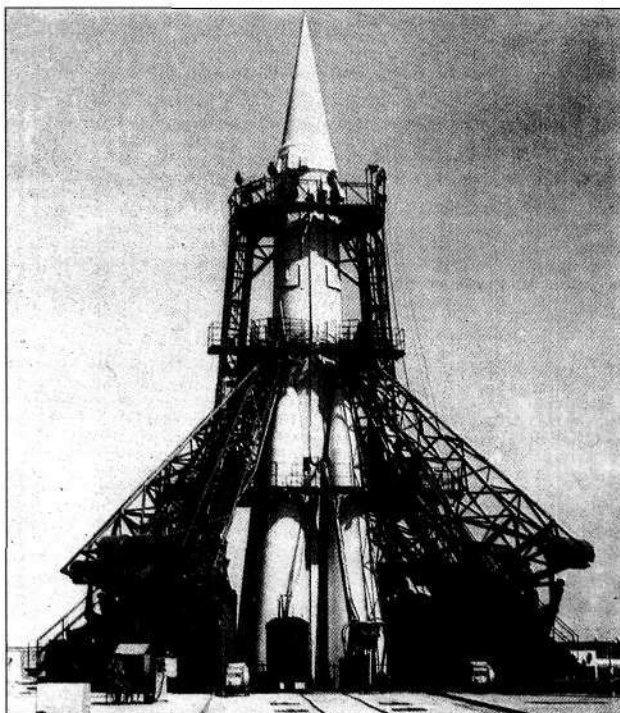
Parts of the inertial control system were located in the central sustainer's (Block A) compartments (mainly in the intertank section) with the radio-package positioned on top of this core unit.

8K71PS - The First Sputnik Launcher

Right from the start of R-7 development Korolyov with utmost clarity visualised it as a feasible and powerful space launch vehicle.

In plans sent to the Soviet leadership on 29 August 1955 Korolyov recommended the launching of artificial satellites, probes toward the Moon and manned spacecraft [14].

On 30 January 1956 the Soviet Government passed a resolution for the development of a heavy artificial satellite called Object D and a special version of the R-7 for its launch into or-



The R-7 experimental model 8K71SN at the Tyura-Tam Test Range during installation tests at the launch pad.

bit (Objects A, B, V and G - in Russian alphabetical order - were designated versions of ICBM warheads [5]).

But Object D proceeded slower than work on the R-7 programme progressed and in December 1956 Korolyov took the decision to first put into orbit "the simplest possible satellite" named PS (which in Russian stands for Prosteshiy Sputnik). Object D later became Sputnik-3.

After the 8K71 suborbital flight of 7 September 1957 [15] (the author takes the liberty of making the supposition that it was an unsuccessful attempt to orbit the first Soviet Sputnik!), the satellite PS-1 opened the Space Age on 4 October 1957.

The first two Soviet satellites PS-1

and PS-2 were launched by basically the same R&D test version of the R-7 ICBM but somewhat modified and designated 8K71PS.

The dummy warhead had been removed of course. Moreover the radiopackage which weighed 300 kg was removed from the top of the central sustainer [16] since there was no need for high pointing accuracy of the payload. This unit was replaced by a conical adapter for attachment of the PS object to the core unit A [16].

The sequence of the core engine's cut-off was simplified. The modified engine RD-108 designated 8D75PS cut itself off upon propellant burn-out without a final thrust stage. At T+100 seconds (T-0 is the moment of lift-off) the strap-on booster engines 8D74PS went over to the first intermediate thrust stage (60.2 tonnes of thrust) in order to push the procedure for dropping off the strap-on boosters up to a higher altitude and decrease dynamic forces on the lightened central sustainer during separation [16].

The 8D74/75 motors of the R&D test version of the 8K71 and respectively the corresponding 8D74PS/75PS engines were still in the early stage of their development and manufacture. They had performance characteristics that were somewhat lower than their original specification. Bit by bit during flight and static tests, numerous changes and improvements were introduced into the engines' design. For the first time the 8D75PS engine's turbopump used hydrogen peroxide with a strength of 82 per cent to drive it instead of 80 per cent as with the earlier R&D engines 8D74/75.

As well as the warhead and radiopackage, the system of vibration measurement RTS-5 (Radio Telemetry System - 5) was removed from the central sustainer [17] of the launch vehicle 8K71PS. The weight of propellant was somewhat decreased and the total weight of the 8K71PS became less than that of the 8K71 ICBM (see Table 1.1).

8A91 - The Sputnik-3 Launcher

During 1956 and 1957, the R-7 ICBM-based two-stage launch vehicle 8A91 was designed by OKB-1 expressly for orbiting satellite Object D.

The 8A91 launcher was fired twice - on 27 April 1958 and on 15 May 1958. The first attempt ended in failure when the launch vehicle broke up at T+88 seconds after blast-off.

8A91 was powered by the next versions of the RD-107/108 motors designated 8D76 and 8D77 respectively. Also these engines were at an early stage of their development. But after

Table 1.1: R&D Test 8K71 ICBM and Launch Vehicles 8K71PS and 8A91.

Specifications	8K71 R&D	8K71PS	8A91
Development years	1954-1957	1956-1957	1956-1958
Stages	2	2	2
Total length, m	33.74	29.17	30.21
Maximum diameter, m	10.30	10.30	10.30
Weight:			
empty (stages+payload), t	27.7	22.1	23.0
propellants, t	246.6	245.2	246.4
total loaded, t	274.3	267.3	269.4
Total launch thrust, t(kN)	398 (3904)	398 (3904)	388 (3806)
Engines:			
strap-on Blocks B, V, G, D (Stage 1)	4 x 8D74 (R&D)	4 x 8D74PS	4 x 8D76
core Block A (Stage 2)	8D75 (R&D)	8D75PS	8D77
Stage separation time from blast off (T-0):			
Stage 1, Blocks B, V, G, D, s	120	126	130
Stage 2, Block A, s	320...330	310	360
Payload:			
weight, kg	5400	83.6	1327
type	Dummy warhead	Object PS-1 (Sputnik-1)	Object D (Sputnik-3)

Note: Weight figures are estimated.

tests and revisions of the R&D engines 8D74/75, some further changes were made to them, an important innovation being that the fuel consumption for feeding the chamber cooling jacket was decreased. As a result the specific impulse increased. The design of the chamber's injector heads was changed.

The central sustainer engine 8D77 produced 15 per cent less thrust than the operational motor 8D75. After T+85s of the ascent the strap-on booster engines 8D76 went over to the first intermediate thrust stage for the same reason as those of 8K71PS.

The sustainer tank's operational pressure was reduced and nitrogen consumption for pressurisation of the core tanks fell about 15 per cent.

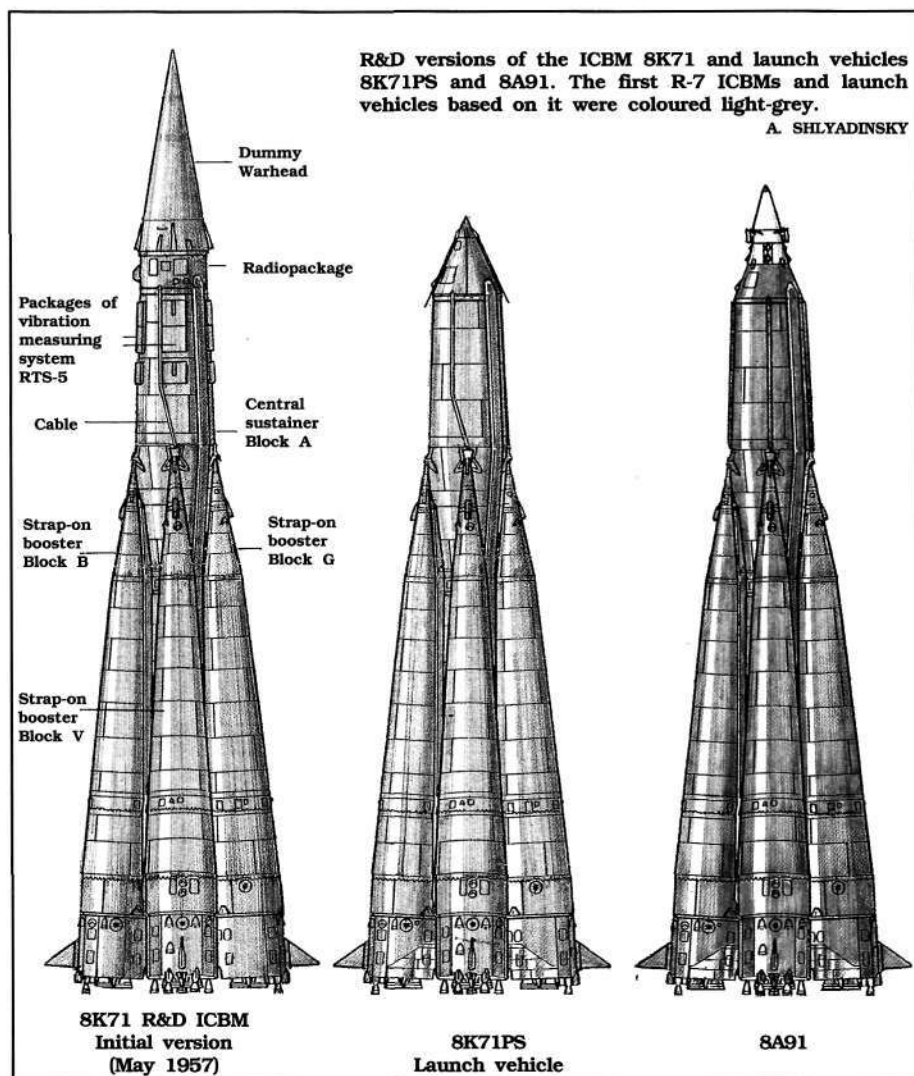
Upon examination of the results of the first trial launches, the operational pressure in the strap-on tanks was reduced too and nitrogen consumption for booster tank pressurisation was 10 per cent less than in the test version 8K71 ICBM and the 8K71PS launch vehicle.

The radiopackage was again absent on the top of the central sustainer. The core engine 8D77 shut down when its propellants were used up without a final thrust stage.

After the two launches of 1958, the 8A91 vehicle was not used again. The next R-7 based space carrier vehicle became the three-stage Moon rocket 8K72, which is the subject of Part 2 of 'Soviet Rocketry that Conquered Space' and is due to appear in a forthcoming issue.

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 17. Baikonur at the Beginning of its Way, p.142.
- (All photos are from the author's papers.)

Table 1.2: Early Versions of the RD-107 and RD-108 Engines, 1954-1957.

Specifications	RD-107: Block B, V, G, D engines (boosters)			RD-108: Block A engines (sustainer)		
	8D74 R&D	8D74PS	8D76	8D75 R&D	8D75PS	8D77
Design organisation	OKB-456	OKB-456	OKB-456	OKB-456	OKB-456	OKB-456
Development years	1954-1957	1956-1957	1956-1957	1954-1957	1956-1957	1956-1957
Oxidiser	LOX	LOX	LOX	LOX	LOX	LOX
Fuel	Kerosene T-1	Kerosene T-1	Kerosene T-1	Kerosene T-1	Kerosene T-1	Kerosene T-1
Thrust: sea level, t (kN)	81(795)	81(795)	81(795)	74(726)	74(726)	64(629)
vacuum, t (kN)	99(971)	99(971)	99(971)	93(912)	93(912)	82(804)
Combustion chamber pressure, atm (MPa)	58(5.69)	58(5.69)	58(5.69)	50(4.91)	50(4.91)	40(3.92)
Specific impulse:						
sea level, s(Ns/kg)	250(2453)	250(2453)	252(2472)	241(2364)	241(2364)	246(2413)
vacuum, s(Ns/kg)	306(3002)	306(3002)	310(3041)	308(3021)	308(3021)	315(3090)
Burn time:						
total, s	140	146	150	340	320	370
main thrust stage, s	120	100	85	300	300	350
Dry weight, kg	1190			1278.5		

Russian Space Shuttle Projects, 1957-1994 - Part 4

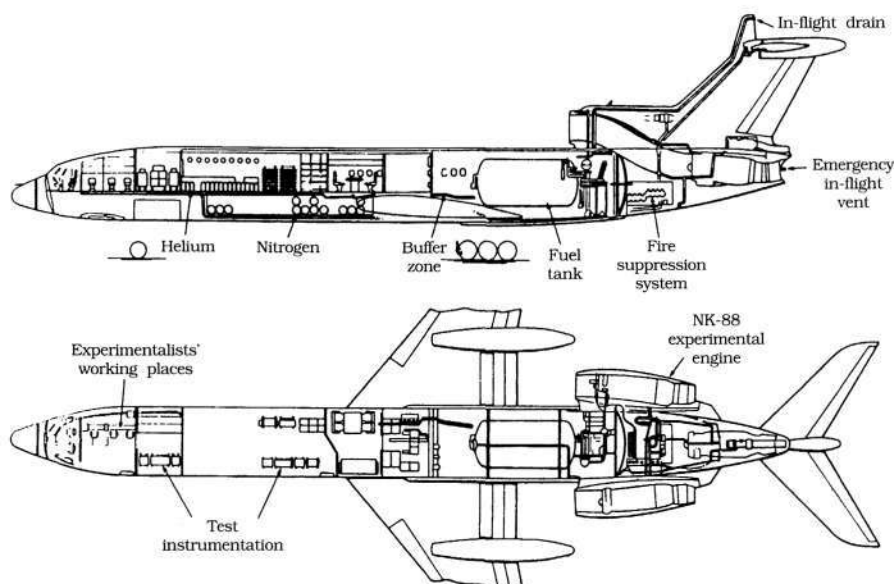
Parts 1 and 2 of this series of articles on Russian space shuttle projects had much to report on their military origins. Part 3 was devoted to the Buran space shuttle and events surrounding its final abandonment.

It would however be inappropriate to leave the subject of Russian aerospace plane development at the point of Buran's decline. That was not the final end of the story. Part 4 now provides the epilogue to the extent that this can be discerned among the upheavals of the Russian economy.

Beyond Buran

Since at least the early 1970s, Russian engineers have put considerable effort and resources into a hypersonic research programme aimed at providing scramjet propulsion for a number of aircraft and missile projects. A scramjet is a type of powerplant in which the airflow inside the motor is flowing faster than the speed of sound; in ordinary jet engines, for example, the air flow within the motor is subsonic. The Russians actually began research into scramjet technology back in 1972, at the Central Institute of Aviation Motors (TsIAM) near Moscow. Many Western analysts believe that the scramjet effort begun at that time may have been part of the effort by the Russians to build the hypersonic aircraft launcher for the Spiral orbiter.

In information released since 1990, the evidence appears to indicate that Soviet research into scramjet engines and Mach 12-20 aircraft in the intervening years remained at a low level until February 1986, when the US Pentagon announced it would fund research into a "National Aerospace Plane," capable of taking off from an airport runway and flying into orbit, and returning to another runway someplace distant. It seems that the announced US initiative gave impetus for the Russians to do the same. The framework for the propulsion system for the first-generation Soviet hypersonic aircraft apparently incorporated a dual engine arrangement - of both turbojets and ramjets. To simplify the fuel system, Russian engineers decided that both types of engines would have to use the same fuel. As a result, two fuels - liquid hydrogen and liquid methane - were looked into. To develop both methane-powered and hydrogen-powered engines, TsIAM converted a Tupolev transport into the Tu-155 (which burned liquid hydrogen in the



- TsIAM has converted the Tu-155 hydrogen fuel test aircraft to the Tu-156 methane fuel test aircraft.
- The alternate fuels are tested in the right engine.

Tu-156 Methane fuel test aircraft.

BY PETER PESAVENTO

California, USA

left engine) and then subsequently the Tu-156 (which burned liquid methane). The propulsor units were modified Kuznetsov NK-88 engines.

It has been revealed that the Russian aerospace plane had been in development since early 1986 at the Tupolev aircraft design bureau, the very same facility that had been assigned to build Spiral's mother craft. The Central Aerohydrodynamic Institute (TsAGI) at the Zhukovskiy Academy in Moscow provided research and test facilities as well as giving engineering and aerothermal data input to the design of the airframe. In May 1992, the former Soviets revealed that the airframe for the "X-30-ski" had been under construction for six years, and was using a sophisticated system to cool the airplane's skin by pumped air. However, according to Dr. David Baker, a noted aerospace analyst in London, the Russian hypersonic effort has been held back "due to restrictions in computing power, and perhaps surprisingly, the availability of specialized engineers."

The propulsion system for the Russian aerospace plane has been envisioned to have a three-phase (or made up of three components) engine. From take-off until Mach 2, a turbojet would power the aircraft; from Mach 2 to Mach 4, an ordinary ramjet (because of the speed of the craft, the air flowing into the engine is

RICHARD WARD, LOCKHEED

"rammed," but the airflow within the engine is still subsonic) would take over; and for speeds beyond Mach 4 until orbital insertion, a scramjet engine. To assist in making smooth transitions between all the different engine phases, a hingeable door within the motor called a "ramp" would, at the appropriate times, swing closed on the turbojet-ramjet section of the engine, and at the same time open the scramjet section to the atmospheric airflow. However, it seems that work on the Russian aerospace plane project was cancelled soon after the failed coup d'etat that resulted in the dissolution of the USSR.

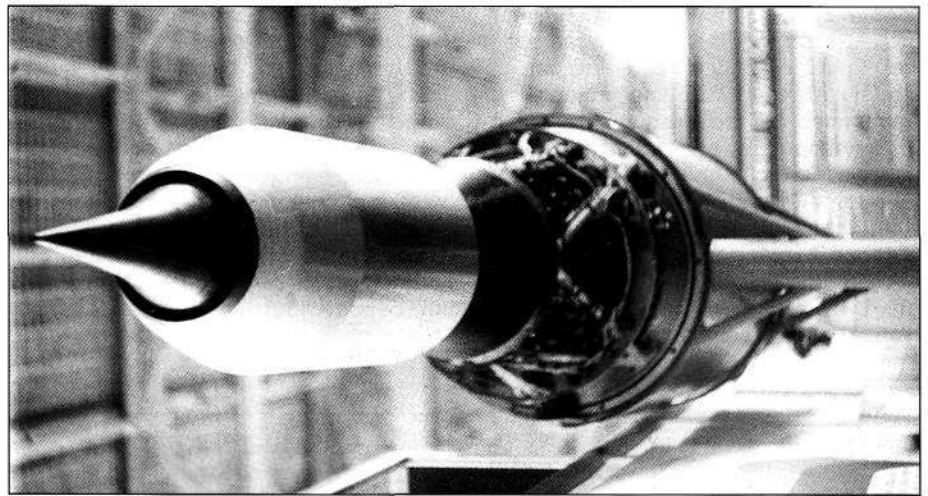
By early 1991, a great deal of testing had been done by engineers at the Baranov Central Aviation Engine-Building Institute and the Lyulka engine design bureau near Moscow. Several bench-test engines successfully used gaseous hydrogen fuel, including a flight-ready engine that worked on liquid hydrogen in 1989. During 1989 and 1990, two unpowered flight tests took place where a scramjet engine was boosted on a shallow trajectory from a launch pad near the Baikonur Cosmodrome carried on a ground-to-air missile. These flight tests qualified the engine configuration, as well as recorded airflow and aerothermal parameters. The missile's flight trajectory was also checked.

On 28 November 1991, the first powered test took place. Due to a desire to keep the test simple, as well as a lack of developmental funds, no

parachute or soft-landing recovery system was built for the stainless-steel-alloy engine. The motor was launched aboard another ground-to-air missile (with a telemetry and propellant module in tow behind the engine), and following its planned test when the hydrogen fuel became exhausted, crashed to Earth about 180 km down range from the launching site. The flight test was a success - at an altitude of 18 km, the airflow inside the engine went from subsonic to supersonic (Mach 3) for five seconds. The engine/propellant module accelerated from Mach 5 to Mach 6, ascending to an altitude of 28 km. During the scramjet's operation, the interior of the motor reached 1800°C. The mission was over in 130 seconds. Russian engineers believe the thrust of the engine was either negligible or small - between 400 and 1100 pounds of thrust. But this was significant, as the engine itself was only a sub-scale model - only 1.3 m in length.

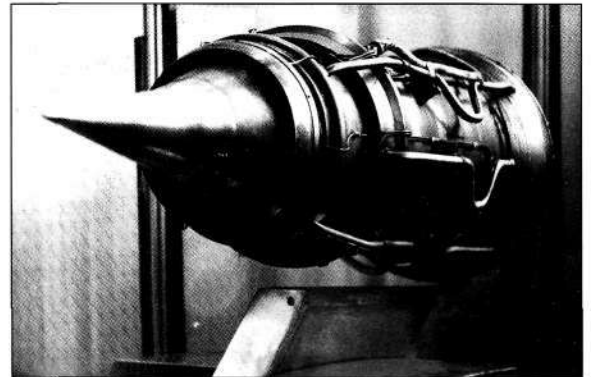
A more ambitious mission was contemplated, where a larger missile and an improved and heavier-built engine would be tested. But the START treaty prevented the use of a larger missile, and funding was tight. However, a cooperative agreement between TsIAM and the French ONERA organization put testing back on track, and a decision was made to repeat the flight test of the previous November. The main difference was that the French would provide the funding and in so doing get to process the data telemetered to the ground.

The second scramjet test took place near Baikonur on 17 November 1992 using a similar mission profile as before, although the flight trajectory was much flatter. The new scramjet motor was essentially the same as the



A three-quarter fore-view of the scramjet engine on display at the Moscow exhibition with its engine cowling cover and telemetry/propellant module attached. GRIGORI OMELCHENKO

A three-quarter fore-view of a scramjet with its engine cowling removed, showing the placement of fuel lines. The engine is mostly made of stainless steel alloys. GRIGORI OMELCHENKO



one used the previous year, but had improved fuel delivery and on-board control systems. At an altitude of 26 km and a speed of Mach 5, scramjet operations took place. The interior of the motor experienced supersonic flow for 15 seconds, although the actual speed of the entire engine/propellant-module assembly only increased to Mach 5.5 (due to a flatter trajectory, resulting in the atmosphere that the test moved through being

more uniform) when the fuel ran out. The mission was over in 100 seconds with the test assembly crashing to Earth 177 km down range.

Since 1992, no other scramjet tests have taken place, most likely due to a lack of funds. However, this hiatus may soon end. In a cooperative agreement between NASA and Russian space officials, a series of scramjet flights operating at Mach 7 will take place, beginning in 1995. NASA and TsIAM officials will use existing hardware - meaning most probably the same kind of engine as used on the two previous tests. But the Russians would like to explore different scramjet inlet configurations. According to TsIAM director Donat Vinogradov, "It's rather difficult to expand the flight test results [of the executed missions] to a real engine, so it will be necessary to change the configuration of the test engine." Such designs include two-dimensional inlet scramjets (which are shaped like a rectangle), of which a 1.7-meter-long scale model has already been tested in windtunnels at Mach equivalent numbers of 4 and 6.2. The scramjets tested in November 1991 and 1992 were of the type called an axis-symmetric inlet engine, whose cross-section is cylindrical, and for which there is no capability of adjusting airflow within the motor, as the walls and intake spike are fixed. Two-dimensional inlet motors provide the ability to adjust the airflow within the engine.

At the Moscow Aero and Industry Exhibition in March 1992, the Russians displayed for the first time a working supersonic combustion ramjet (scramjet) engine. This picture shows a diagram of the engine with its telemetry/propellant module attached. The information below the picture states the engine was flight tested in November 1991 - first in the world.

GRIGORI OMELCHENKO



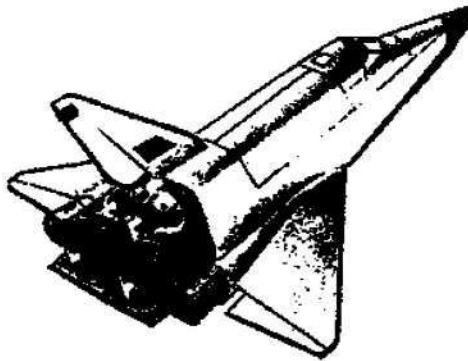
MAKS Project - In The Ascendant?

In 1991, while the final preparations for a powered scramjet were taking place, a new space plane project was announced by the Russians as being in development at Lozinskiy's NPO Molniya. Called MAKS (an acronym for *Mnogotselevaya Aviatsiyniya Kosmicheskoye Sistema*, or "Multi-purpose Aerospace System"), the two-person spacecraft would be launched off the back of an Antonov 225 transport plane built in the Ukraine. The payload that the MAKS vehicle could haul into orbit would be small - between 8½ and 9½ tons. One unique feature is the rocket engine, the RD-701, which uses three propellants. During the launch phase of the mission, the mini-shuttle would burn liquid oxygen/hydrogen and kerosene all at once; once the craft was high enough in the atmosphere (after the kerosene was completely used up), the shuttle would use the remaining liquid oxygen/hydrogen for achieving orbit. Due to the limited amount of propellant able to be carried on board, the kerosene propellant element is needed to provide the necessary extra thrust to get the space vehicle into the upper reaches of the atmosphere.

At present, the MAKS project is actively courting foreign investment, as the roubles necessary to fund the project within the CIS are inadequate. (Indeed, in December 1993 the Russian government put its participation in the project on hold due to lack of discretionary funding.) The Russians have been wooing European Space Agency officials, as well as representatives of British Aerospace, to consider using the system in some form. Already, mock-ups of the orbiter and external tank have been constructed, with most of the design documentation completed. One Antonov 225 transport is available and another nearly complete. The Russians are so confident of gaining foreign investment that the cryogenic base for the fuelling of the MAKS system has been installed at the Baikonur Cosmodrome, an anticipated launch area. As of early 1994, 1.5 billion roubles (about \$1.25 million US dollars) had been spent. Perhaps the most promising joint venture connected with the MAKS project is that of NPO Energomash (constructors of the RD-701) and the US aircraft engine manufacturer Pratt & Whitney. In the Summer of 1994, the first hot-fire tests of the injectors of the RD-701 were begun at NPO Energomash's laboratory facility north of Moscow. In 1995, further test firings of the rocket motor will take place at NASA's Marshall Space flight Center in Huntsville, Alabama.

NPO Molniya engineers envision the MAKS programme to have its first crewed flight within six years, with two Antonov transports, complemented by

three MAKS orbiters and 12 external tanks (the number of tanks must be preliminary, as the tanks are destroyed upon atmospheric reentry during the shuttle's ascent into space). The number of missions annually, optimistically projected to start in 1998, would eventually average between 25 and 50 launches (with ten to 15 missions being for foreign commercial customers). According to Russian aerospace journalist Sergei Leskov, the quoted number of annual launches



MAKS Orbiter.

is purely for profitability calculations, and he notes that such numbers "far exceed the needs of today's space program... But spending on such projects in our country has a habit of growing incredibly."

In 1994, a new aerospace plane project was announced. Begun in late 1993, the Russian Space Agency initiated a project called Orel ("Eagle"). Again, TsIAM is the prime research facility. The Russians are planning to prepare and launch a winged flying laboratory called IGLA (*Ispietaniya Gierpersonicheskii Laboratoriacheskoye Apparatus*, or "Hypersonic Research Vehicle") - a seven-ton, eight-meter-long, delta-winged vehicle that could be launched on top of a surplus Soviet ICBM missile. The craft could ultimately attain speeds of Mach 16 at altitudes approaching 21 km. The project is thought to cost (over a five-year period) about 40 billion roubles (about \$3.7 million US dollars). But there is opposition by the US Pentagon to both Orel and further scramjet testing by the Russians - it has been theorized that the US would be funding the next-generation ex-Soviet cruise missile, which would be difficult to bring down if fired in anger at the United States.

The old ways die hard. In the Autumn of 1993, Gleb Lozino-Lozinskiy was fired from his position as Director at NPO Molniya, and replaced. A veteran of three space shuttle projects, and the initiator of a fourth, Lozinskiy was too used to following government-sanctioned directives. The bottom line was that he was unable to find new markets for NPO Molniya's products during Russia's on-going economic restructuring.

What The Future Holds

It appears that 1994 was indeed the end of the Russian dream to fly crewed winged space vehicles. By mid-1994, all funds allocated for the active storage of the Buran space shuttle dried up, and NPO Molniya was put on notice that no additional roubles for mothballing the components would be forthcoming. The death-knell for Buran's rocket booster - the *Energiya* - was also sounded, when the Russian Space Agency and the Russian Ministry of Defence made a decision in August 1994 to construct a new heavy-lift rocket (capable of putting 100 tons into orbit) called the *Angara-24*.

The upheavals in the Russian economy have also effectively cancelled the MAKS project. According to correspondent Petr Yevseyev, "By now the MAKS project and other aerospace projects, existing for example at the Raduga Design Bureau, have for all intents and purposes been put off by the government to better times. The Russian Space Agency points out the difficulties with funding and necessity for an analysis of needs for constructing new aerospace systems so that after their construction they will not remain unused like the Buran". One of the unfortunate aspects of the fall-out from this decision is that the second *Mriya* transport aircraft for MAKS has been abandoned - despite being nearly 85% completed. It seems that TsIAM's Orel project has also fallen victim, destined to remain an undertaking on paper only.

But there remains one bright spot - in a storage shed somewhere on the lands owned by the Tupolev aircraft design bureau lies a completed airframe for an aerospace plane (although some Western analysts believe that - following standard Tupolev operating procedure - two prototypes may have been built). There is a commitment by the leaders of this design bureau to have Tupolev 2000 completed by 2010 - with a take-off weight of 90 tons, using liquid hydrogen as fuel, and carrying a two-person crew. But at the present the aerospace craft remains engineless: a technological feather of the Fire-bird heroine Marushka.

Acknowledgements

The following people I would like to thank for their efforts, information, and contacts during the writing of this article. Kazakhstan: Valeriy Antipov. Russia: Valeriy Avraamov; Alexander Velovich; Grigori Omelchenko; Albert Nabiulin; Valentina Markusova, and others. UK: Phil Clark, Rex Hall. USA: Michael Cassutt; Dr Ronald Bogaard; Richard Ward; Jay Miller; Tim Linder; Richard DeMeis; Phil Pesavento, and others.

A selected bibliography relevant to Parts 1 to 4 of this article may be obtained on request from the author, c/o the *Spaceflight* Office.

The Moon: Our Next Logical Step ?

Nowadays there seems to exist a general belief that the Moon is a boring place. The purpose of this article is to argue that, on the contrary, for the near future the Moon is the most important Solar System body other than the Earth itself.

During recent years, in the post-Apollo era, the importance of the Moon has been artificially reduced. It seems as if the missions in the 60s and 70s had performed all the investigations worth doing there. Even space enthusiasts, such as Carl Sagan, propose bypassing our satellite and going directly to Mars [1], but sending a manned Mars mission directly from the Earth would probably be as much a dead end as was the Apollo program due to its high cost.

Why return to the Moon? Well, it is about 95 per cent (in terms of energy) of the way to the planets. A look at the potential well model of the Earth-Moon system gives a vivid impression of this discussion [2].

If water exists at the lunar South Pole, as indicated by Clementine, it would be of extreme importance both for sustaining people in a lunar base, and for chemical fuel (once dissociated as H_2 and O_2) or for nuclear rockets (acting as a working fluid). So, it seems mandatory to send a dedicated experiment in a lunar probe to look for water at the poles. Such an instrument, a gamma ray spectrometer (GRS), has been in the plans for many lunar probes but has never flown (apart from on two Apollo command modules in an equatorial orbit). Recently, the Lunar Discovery Orbiter mission included a GRS as one of its central instruments [3], not only to look for water, but also to map the distribution of various elements over the lunar surface, which can be of interest by themselves.

The Moon can act as a test bed for many new approaches to space exploration. Solar sails would be in a far more convenient environment compared with that of the Earth with its stronger gravity, the presence of atmospheric drag and the possibility of collision with other orbiting objects. It is a perfect place to use new launch approaches, such as the electromagnetic launcher proposed by A.C. Clarke so long ago [4]. Even for classical rockets there are many advantages, not only in the reduced lunar gravity and lack of atmosphere, but also the possibility of doing Earth gravity assists.

It is quite obvious that space conditions cannot be accurately reproduced in the laboratory, and we do not know

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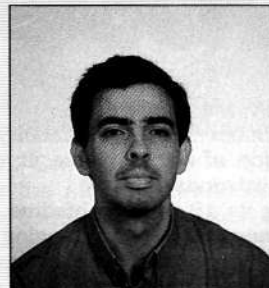
how a long exposure to space affects diverse materials. It would also be important to test life support systems for extended periods of time and to study long-term effects of reduced gravity on the human body, only to cite a few examples. The lessons learnt on how to build a self-supporting habitat in a fractional g environment (as on the Moon) would be of unquestionable interest for the settlement of bases on other worlds.

From a scientific point of view there is no question that the Moon is a superb place. Astronomers could put their telescopes in an environment of reduced gravity without an atmosphere to disturb the image and, even more important, could observe objects continuously for several days at any wavelength, improving the time and spectral coverage of interesting events. The best place for radio astronomy is the far side of the Moon because it is the only place in the Solar System which is permanently free of human-made interference (up to now, at least). In this respect, the Moon could be a very convenient place for SETI, which in case of a positive detection would be the most important event in human history. Geology can open entire new fields of work, ascertain the origin of the Moon, study how materials evolved in these different conditions and which minerals formed, only to cite a few.

Medicine and Biology would have a planetary-sized laboratory to investigate the effects of gravitation, day-to-night changes and the psychological effects of a strange environment. Some illnesses could best be treated in low g environments, such as cardiac diseases. Virtually, any branch of science would be boosted by lunar research facilities.

The social effects could be of even greater importance. First of all, people on the Earth would become acquainted with space. A close similarity can be found with antarctic missions. When new and interesting results start to come from the Moon the acquaintance will turn into real interest and, in this way, into increased budgets for

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Jordi L. Gutierrez holds a BSc in Physics and a Degree Thesis in Astrophysics, both by the University of Barcelona. Currently he is near completion of his PhD while teaching Algebra, Theoretical Mechanics and Astronomy at the same university.

In the summer of 1994 he graduated in the Summer Session of the International Space University.

He has been interested in astronomy and space since his childhood when he explored the universe with a 75 mm refractor telescope.

space exploration in general. It is also important to recall that every new environment has had important inputs into human culture.

Finally, we must take into account the serendipity factor. Do not forget that Columbus was searching for a westward route to Japan when he discovered America.

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One-page INTO SPACE articles offer readers the opportunity to express their ideas and 'think aloud' on space topics which they see as important and of interest to others. Contributions of an appropriate (one-page) length may be sent to the editor at any time and should be accompanied with a photo of the writer (head and shoulders) and a few lines of personal details.

Infrared Space Observatory

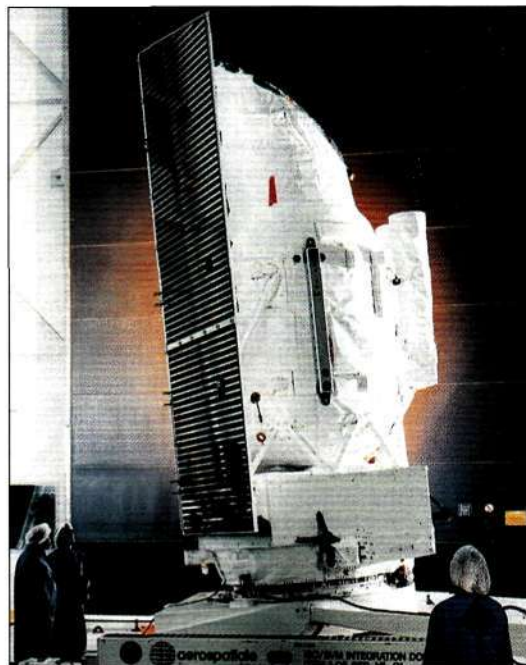
ESA's Infrared Space Observatory (ISO), which is scheduled for launch in September 1995, is a facility of unprecedented sensitivity for the exploration of the Universe. It will have an impact on virtually every field of astronomy.

During its 18 months lifetime, ISO will be used to observe all classes of astronomical objects, ranging from planets and comets in our own Solar System to the most distant extragalactic sources. It will be used to investigate very weak heat sources in the Universe (such as the gas and clouds in which stars are being born), the formation of planetary systems like our own and the evolution of galaxies. The results of ISO's infrared measurements will give astronomers new insights into the history and development of the Universe.

ISO's infrared instruments - a camera, an imaging photopolarimeter, and two spectrometers - will be up to a thousand times more sensitive than any other infrared astronomical instruments. This is due to the fact that the satellite will operate outside the Earth's atmosphere,

which would otherwise absorb most of the infrared radiation, and to the fact that the instruments will be cryogenically cooled to the temperature of liquid helium (about -270°C).

ISO will be launched by an Ariane-44P vehicle into an Earth orbit with a 24 hour



ISO ready for lift-off in September, waiting in cryogenic condition, i.e. deep-frozen by superfluid helium. ESA/ESTEC

period (1000 km perigee and a 70,000 km apogee). It will spend 16 hours per day outside the Earth's radiation belt. This, together with its network of three ground stations, will enable astronomical observations to be made for about 16 hours per day.

ISO is 5.3 m high, 2.3 m wide and will weigh approximately 2500 kg at launch. It consists of a Payload Module (the upper cylindrical part in the figure), a Sun shield covered with solar cells to generate electrical power, and a Service Module (below), which provides all the traditional spacecraft services such as power, data handling and attitude control.

ISO carries four scientific instruments, which have been developed in Europe. These are: a camera, a photopolarimeter, a long-wavelength spectrometer and a short-wavelength spectrometer.

The Payload Module

The Payload Module is a large 'cryostat' 2.3 m in diameter and weighing 1.5 tons. This is effectively a very large

Top: Tip to tip, this jet spans slightly more than a light-year. The fountainhead of this structure - the young star - lies in the dark middle of the jet, being hidden from view behind a dark cloud of dust. The nearly symmetrical blobs of gas at either end are where the jet has slammed into interstellar gas.

Bottom left: A close-up of a region near the star reveals a string of glowing clumps of gas, ejected by the star in machine-gun like burst fashion. This provides new clues to the dynamics of the star formation process. The jets are ejected from a whirlpool of gas and dust orbiting the young stars.

Bottom right: This arrowhead structure is a classic bowshock pattern produced when high-speed material encounters a slower-speed medium. Young stellar jets were discovered 20 years ago, in part due to visible-light observations of bright patches of nebulosity (called Herbig-Haro objects), which appear to be moving away from associated protostars.

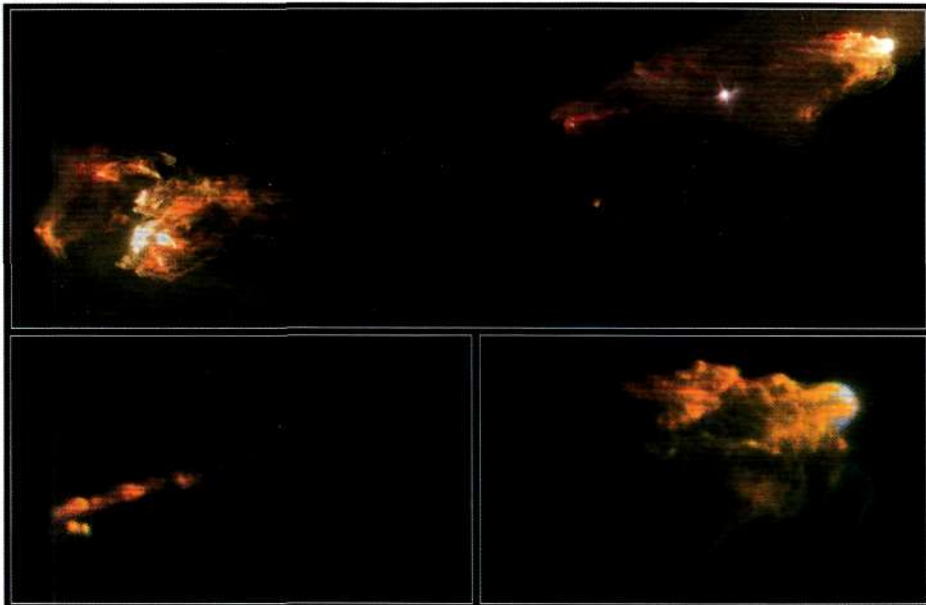
J. HESTER (Arizona State University),

WFPC 2 Investigation Definition Team, and NASA

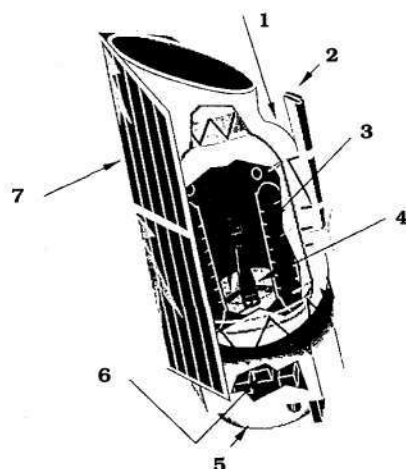
New Hubble Results

Jets from Young Stars

A star forms through the gravitational collapse of a vast cloud of interstellar hydrogen. According to theory, and confirmed by previous Hubble pictures, a dusty disk forms around the newborn star. As material falls onto the star, some of it can be heated and ejected along the star's spin axis as opposing jets. These jets of hot gas blaze for a relatively short period of the star's life, less than 100,000 years. However, that brief activity can predestine the star's evolution, since the final mass of a star determines its longevity, temperature, and ultimate fate. The jet might carry away a significant fraction of the material falling in toward the star, and, like a hose's water stream plowing into sand, sweeps out a cavity around the star that prevents additional gas from falling onto the circumstellar disk. The picture below was taken by Hubble's Wide Field Planetary Camera 2 of Herbig-Haro objects (HH1/HH2) lying 1,500 light-years away in the constellation of Orion.



thermos flask filled with some 2400 litres of liquid helium, which 'boils' very slowly at a temperature below -270°C. The scientific instruments are mounted on a 60 cm-aperture telescope installed inside the



1. Payload module (cryostat); 2. Star trackers; 3. Superfluid helium tank; 4. Telescope with scientific instruments; 5. Interface with Ariane; 6. Service module; 7. Sun shield with solar cells.

cryostat.

The latter is enclosed in thermal blankets and is shaded from direct sunlight by the Sun shield mounted on its side.

Critical technology developments started nearly ten years ago have culminated in the delivery of a unique flight-model Payload Module for ISO by European industry. DASA has been responsible for the Payload Module's development, Linde AG (Germany) for the cryogenic subsystem and Aerospatiale (France) for the telescope. The ISO satellite has been built by an industrial consortium of some 35 European companies, led by the Satellite Prime Contractor, Aerospatiale, based in Cannes (France).

Mirror Blanks for IR Optics

HERAEUS, Byfleet, Weybridge, Surrey, England is the supplier of critical components for ISO having provided high quality mirror blanks for the central components of the satellite's optical system which needed fused quartz glass with high homogeneity and a low coefficient of thermal expansion. Fused quartz glass is easy to polish and can also withstand the hostile conditions of launch and orbit - another critical characteristic for satellite applications.

Because the ISO telescope will measure infra-red radiation, its components must be highly sensitive and also super-cooled to about 2°K (-271°C) to suppress internal and background radiation, which would interfere with the instruments performance.

Heraeus has a long tradition of supplying fused quartz and fused silica for space optics applications. Heraeus materials provided lightweight mirror blanks used in early Earth observations. NASA used Suprasil in the corner cube arrays placed by astronauts on the Moon during several Apollo missions. These were used, among other things, to measure the exact distance between the Earth and Moon.

No Escape to Titan !

BY PATRICK MOORE

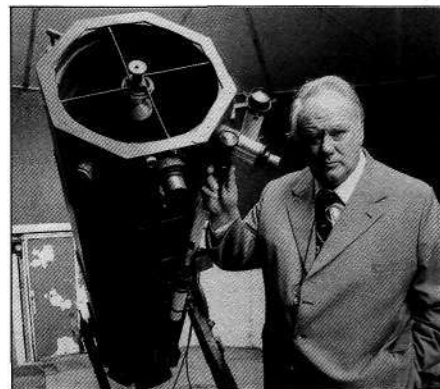
BIS Fellow

There has been considerable discussion lately about Titan, the largest satellite of Saturn. Undoubtedly it is a fascinating place. It is larger than the planet Mercury, and has a dense atmosphere made up chiefly of nitrogen, with a good deal of methane. Voyager pictures showed only the top of the layer of orange "smog", but recent Hubble images show detail, and there seems every possibility that the surface contains chemical lakes or even a chemical ocean.

We know that life on Earth will not exist for ever - and neither will the Earth itself. The Sun is evolving; in time it will leave the Main Sequence and become a giant, so that the inner planets (Mercury and Venus) will be vaporised, and in all probability the Earth will follow suit. In any case, the Earth will cease to be habitable. This will not happen for several thousands of millions of years (at least, we hope not!) but when the danger is close - what then? If Mankind still persists, there have been suggestions that we might emigrate to Titan, as being the only world in the Solar System, apart from Earth, which has a nitrogen-rich atmosphere.

Let us look at the other candidates - beginning with Mars, which has a definite, if thin atmosphere, and coming down to Titania, the largest satellite of Uranus, which has none. In descending order, they are shown in the table below.

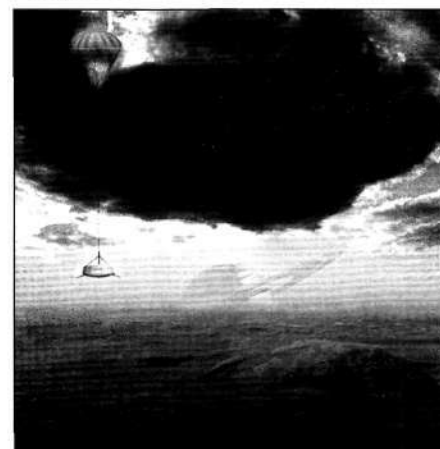
We can safely dismiss all worlds smaller than Titania as being airless, or virtually so. But obviously there is a curious factor. Titan has a dense atmosphere - much denser than that of the Earth - while Mercury, for example, has almost none; yet Mercury's escape velocity is much greater than that of Titan. Superficially it seems strange, but there is a straightforward answer. The ability to retain an atmosphere depends partly upon escape velocity, and partly on temperature. The daytime temperature of Mercury can exceed +400 degrees C, while that of Titan is of the order of -170



degrees C. The hotter a body, the quicker the atoms and molecules can move around, and the easier they can break free; with intense cold, the movements are slowed down and they are retained.

And this is why we can hope for no salvation from Titan. When the Sun becomes more luminous, Titan will be heated - and even an increase of a few degrees will be enough to make the atmosphere escape. By the time that the Sun has reached the giant stage, Titan will be airless.

It seems a pity - but at least Titan offers us a challenge; in my mind it is just about the most intriguing world in the Solar System, and I can hardly wait till 2004, then - if all goes well - the Huygens spacecraft will touch down there and tell us what Titan is really like.



The Cassini mission to Saturn is due to arrive at the planet in 2004 and will carry ESA's Huygens probe which will be dropped into Titan's atmosphere as illustrated by this artist's impression. ESA

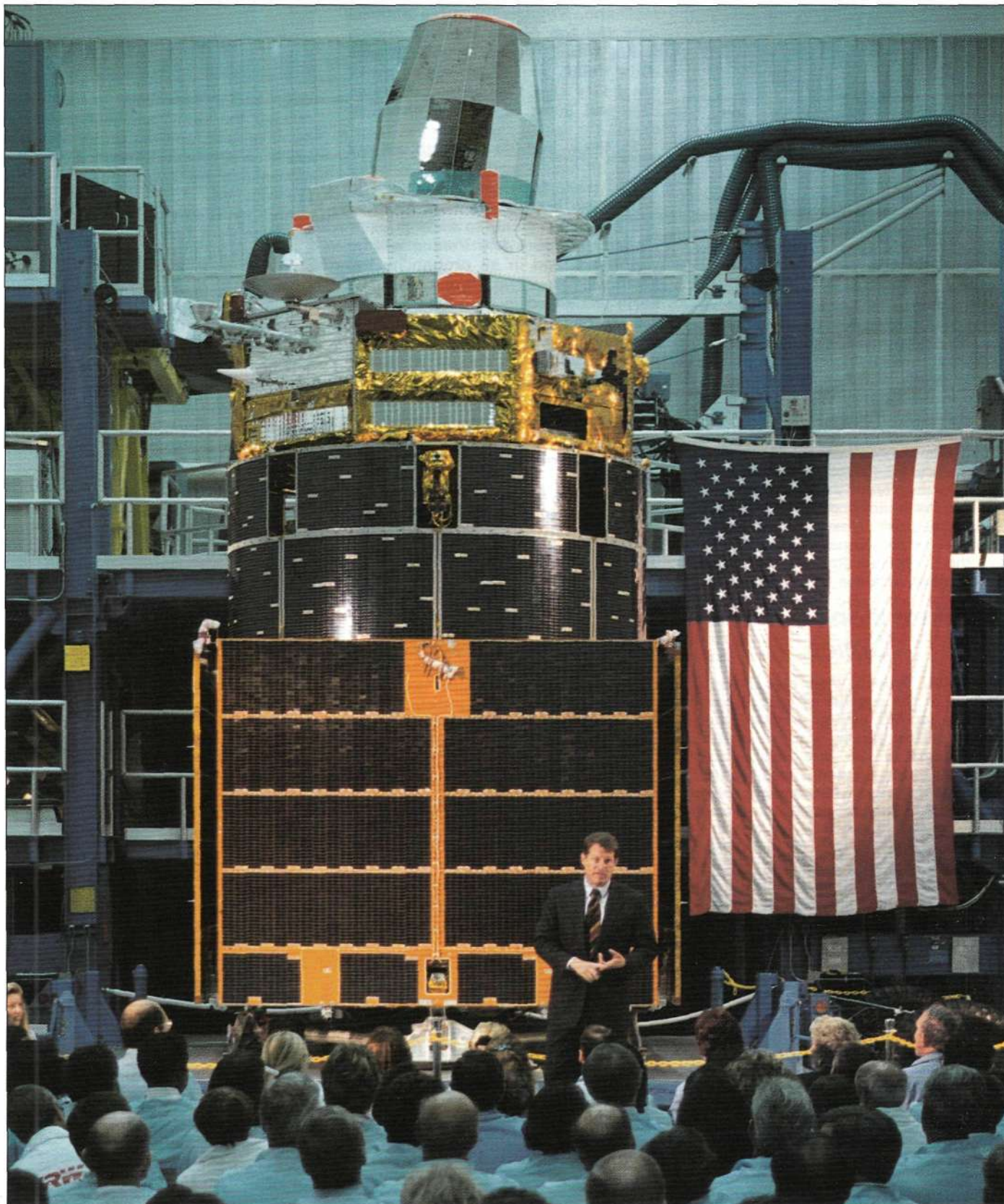
	Diameter, km	Escape velocity, km/s	Atmosphere
Mars	6794	5.03	Thin; mainly CO ₂
Ganymede	5268	2.78	None
Titan	5150	2.47	Dense; mainly nitrogen
Mercury	4878	4.25	Inappreciable
Callisto	4808	2.43	None
Io	3660	2.56	Very tenuous
Moon	3476	2.38	Inappreciable
Europa	3130	2.10	None
Triton	2705	1.44	Very thin; mainly nitrogen
Pluto	2324	1.18	Tenuous
Titania	1578	1.6	None

"Assured Access to Space"

Defense Support Program (DSP) satellites have been the spaceborne segment of NORAD's Tactical Warning and Attack Assessment System since 1970.

TRW builds DSP spacecraft and integrates payloads provided by Aerojet of Azusa. Vice President Al Gore is seen here addressing employees in the DSP integration test area at TRW's Space & Electronics Group facility in Redondo Beach, California.

TRW



BY ROGER G. GUILLEMETTE
Rhode Island, USA

On 22 December 1994 USAF Defense Support Program Flight 17 (DSP-17) was successfully launched on a Titan IV/Centaur launch vehicle from Cape Canaveral Air Station after a delay of over two months. But with this delay following on previous delays the question is whether the Titan IV programme can live up to its well-publicised motto of "Assured Access to Space"?

Introduction

Built by TRW Space & Electronics Group, the 2360 kg DSP-17 satellite uses infrared sensors to detect strategic and tactical ballistic missile launches, space launches and nuclear detonations. DSP satellites have been the spaceborne surveillance segment of the Tactical Warning and Attack Assessment System since 1970 and have proven to be highly reliable as orbital sentries.

During Operation Desert Storm, DSP satellites gave coalition forces forewarning of every SCUD missile attack in the conflict.

The launch of DSP-17 marked the fourth consecutive successful launch of the trouble-plagued Titan IV, the United States' most powerful unmanned booster. The previous three successful launches were all earlier in 1994 on 7 February, 3 May and 27 August. US Air Force officials pointed to the mission as proof that the Titan IV programme was back on track after a series of setbacks, including a 1993 explosion at Vandenberg AFB that destroyed the \$330 million Martin Marietta-built launch vehicle and its \$800 million payload, a trio of White Cloud ocean surveillance satellites.

Spacecraft Contamination and Toxic Propellant Leaks Prove Costly for 1994

The long saga of DSP-17 began on 9 September 1994 when USAF officials announced that technicians, while performing routine pre-launch operations, discovered that the early-warning satellite was contaminated with a substance believed to be dust.

The DSP spacecraft was thoroughly cleaned and the Titan IV's nosecone was re-installed. Launch preparations again moved forward; however, the initial investigation failed to pinpoint the source of the contaminants, a cotton substance that was not used in either launch or payload preparation.

Launch preparations were again brought to a halt when, less than a month later, the DSP-17 spacecraft was contaminated by foreign sub-



America's orbiting sentries. The Defense Support Program (DSP) system is a survivable and reliable satellite-borne system that detects and reports on real-time missile launches, space launches and nuclear detonations. Its infrared sensors are designed and built by Aerojet who has been developing surveillance sensors for DSP since the late 1960s. AEROJET

stances for a second time after technicians turned on an air conditioning unit within the nosecone.

The DSP satellite was once again cleaned, while Air Force officials flew in an independent investigation team of the 14th Air Force located at Vandenberg AFB, California, which is the primary launch site of Titan IVs destined for polar and near-polar military missions.

This time, the spacecraft was found to be covered with cotton and synthetic fibres, paint chips, and fibre-glass fragments. Once again, no single source of the contaminants was discovered by the investigators. And once again, the launch date was pushed back another six weeks to a new date of 16 December 1994.

Air Force officials attempted to put the matter in a good light as technicians began the arduous job of cleaning away the microscopic particles for the second time in as many months.

On 15 December 1994, however, a bad seal on a Titan IV storage tank caused about 200 gallons of highly-toxic nitrogen tetroxide to spill from the vehicle. The exposed chemical then formed a poisonous red-vapour cloud, forcing the evacuation of Launch Complex 40 and sending seven pad workers to hospital for observation.

A team of technicians, wearing special protective suits, was able to plug the leak and later replaced the faulty seal on the 800-gallon tank, which is attached to one of the Titan's solid rocket motors. Consequently, the launch date was slipped for the third time.

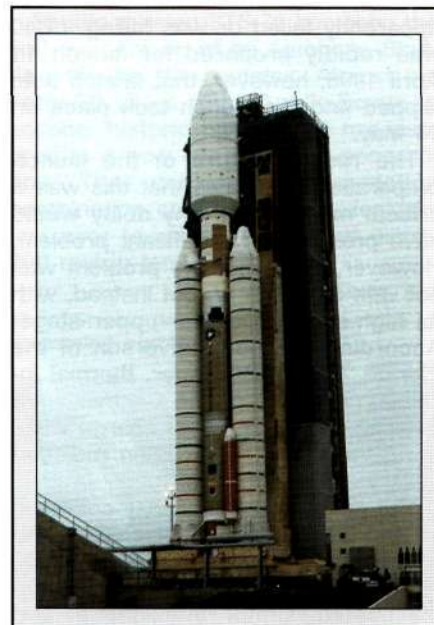
Finally, on 22 December 1994, the

20-storey Titan IV coupled with an Inertial Upper Stage, lifted off into an overcast sky at 5:19 PM EST and quickly vanished from sight into a low cloud deck. Six hours after launch, the DSP-17 spacecraft separated from its upper stage and was inserted into a perfect orbit.

Air Force officials were delighted and undoubtedly relieved by the successful launch of the Titan IV and its vital payload.

"This launch rate is unprecedented for the Titan program and confirms [that] the nation's heavy-lift capacity can meet a warfighter's needs," em-

A Titan IV heavy-lift vehicle sits poised on Complex 41 at Cape Canaveral Air Station on 22 December 1994 ready to carry a classified DoD payload into orbit. USAF



phasized USAF Major General Robert Dickman, then-Commander of the 45th Space Wing.

However "unprecedented" a fourth Titan launch in one year from CCAS might be, it is still a far cry from the self-proclaimed goal of the Air Force's \$26,000,000,000 Titan IV programme and its well-publicised motto - "Assured Access To Space."

The setbacks which plagued the DSP-17 launch were precisely the types of trouble that the Air Force has been working hard to avoid, especially after one of the previous Titan IV vehicle, carrying a secret signal-intelligence payload, spent 1,054 days sitting on the launch pad before finally lifting off in 3 May 1994.

Every day that a Titan IV sits stacked on the pad in preparation for launch costs an estimated \$2.5 million. Estimated cost of the 88-day delay in launching DSP-17 - approximately \$220 million.

Titan IV Launches in 1995

An aggressive Titan IV launch programme is underway with three launches from Cape Canaveral Air Station in 1995. The first on 14 May was a classified payload which is reportedly an electronic intelligence satellite now in geosynchronous orbit. The next will be the second Milstar I military communications satellite in late September. A fourth classified launch is set for September from Vandenberg AFB, California.

A Titan IV/Centaur with its classified payload was rolled out to Launch Complex 41 (LC41) on 22 September 1994. However, a second Titan IV/Centaur with another classified payload was transported to Launch Complex 40 (LC40) in late January 1995 and the bulk of the manpower resources were immediately shifted to preparing that vehicle for launch.

The LC40 Titan IV was reportedly a "call-up" launch, which indicates that its payload was probably destined to replace an on-orbit asset which had apparently failed or was failing. LC40 was rapidly prepared for launch 11 April 1995; however, that launch date slipped and the launch took place on 14 May.

The rushed nature of the launch preparations indicates that this was a critical mission and any delay would have presented a significant problem. However, this time, the problem was not with the Titan IV, but instead, with its high-energy Centaur upper stage. According to Todd Halvorson of the *Florida Today* newspaper, thermal insulation blankets on the Centaur were building up an electrical charge while flying through the Van Allen radiation belts that surround Earth.

The static electricity that collected on the Centaur could discharge and damage sensitive electronic components, potentially fatal for the very sophisticated signal intelligence and



A Titan IV/Centaur is successfully launched from Complex 40 at Cape Canaveral Air Station at 09:45 EDT on 14 May 1995 on a due east azimuth to achieve an equatorial orbit for its secret payload. PETER GUALTIERI, WEST KENTUCKY NEWS

electronic eavesdropping satellites launched by Centaur for the DoD and US intelligence agencies.

Both Titan IV missions were delayed while new insulation blankets were manufactured and installed on the Centaurs.

Launch controllers conducted a dress rehearsal for the LC41 Titan IV/Centaur mission in early April. Both Titan IVs are equipped with a massive 26.2 m fairing, the largest payload shroud available for the vehicle, suggesting that both payloads may be large signal/electronic eavesdropping satellites (SigInts), which feature huge collapsible dishes (up to 100 m in diameter) designed to 'scoop up' a variety of electrical or radio signals. The requirement for the Centaur upper stages indicates that both payloads are destined for either a geosynchronous or Molniya-type (12 hour) orbit.

The progress of the 1995 launches is being closely monitored as an indicator of whether the Titan IV pro-

gramme has "turned a corner" after its history of setbacks and delays. Many questions remain unanswered and both the US Air Force and the prime contractor, the newly-merged Lockheed Martin Corporation, find themselves faced with the continuing need to demonstrate that their \$330,000,000 booster can deliver vital payloads to orbit, safely and on-time. If that mission cannot be met, "Assured Access to Space" will remain nothing more than a catchy slogan.

Acknowledgments

My thanks to Todd Halvorson and Jim Banke of the *Florida Today* newspaper for their continued assistance, as well as Mark DeCotis, OnLine Services Editor and Sysop of the *Florida Today Forum* on the CompuServe Information Service. I also wish to acknowledge 2d Lt. David W. Honchul, USAF, Chief of Media Relations of the 45th Space Wing for his cooperation in providing the Titan IV photos used in this article.

A Mir Matter of Change

During its tenth year of operational life, the Russian Mir complex is undergoing big changes. Modules and solar panels are being added and repositioned while the number of foreign 'visitor-cosmonauts' keeps on growing. But also the style of doing business aboard Mir is changing where hardware is concerned. A steady stream of non-Russian equipment is being added to what proves to be a good testing ground for the real International Space Station.

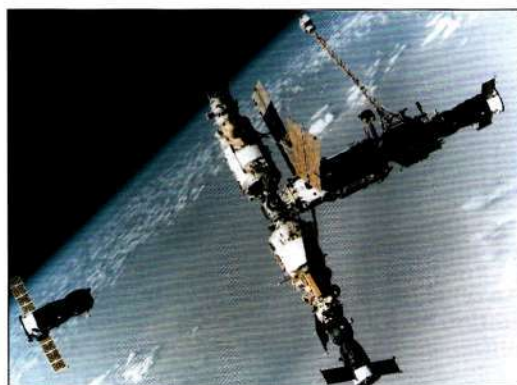
1995 began with the spectacular rendezvous of Discovery with the Mir orbital complex, coming to within 11 m of the docking port on Kristall. It gave the world the first close-up view of the Russian station, and the Americans the experience needed for future actual dockings.

On 16 March American astronaut Norm Thagard joined those working aboard Mir as part of the Mir 18 crew. Thagard is the first 'man-in-the-field' for NASA regarding missions with NASA cooperation on Mir. He has been exploring the station complex with regard to radiation levels, acoustic conditions and comparing the real-life situation on board to the simulated conditions during training on mockups at Star City. He has noted several dis-

crepancies, which will be of advantage to the next Americans to fly on Mir.

Thagard played an important role during the May EVAs to move a solar panel from Kristall to Kvant-1, monitoring Mir's systems and the spacesuits of his Russian colleagues. In fact, during these EVAs, Thagard was the only one actually on board Mir! Who would have expected an American 'crew' on Mir when it was launched back in the Soviet days...

Again the Strela crane proved a very useful tool during the solar battery transfer. This telescopic arm of 12 m maximum length is manually operated by a cosmonaut, enabling quick transport of crew and hardware over relatively large distances.



Mir in its latest configuration before the solar panel move and the docking of Spektr.

COURTESY: ALCATEL and Th.P./SIC

On 1 June, the new module Spektr docked with Mir on its first attempt, a welcome change from the difficulties experienced with Kvant-1, Kvant-2 and Kristall. Besides new experiment-hardware, including 755 kg of US hardware for use by Thagard, Spektr added four large solar panels to Mir's ailing power system. (During the solar panel transfer, there was not enough power to use the Altair geostationary satellite for transmission of the EVA footage).

To facilitate installation of the two extra solar batteries, Spektr's original configuration was changed, and some Earth observation instruments seem to have disappeared from Spektr's payload.

A major foreign instrument carried by Spektr is MIRAS. This grille spectrometer is a collaborative effort by Belgium's Alcatel ECTA, Russia's RKK Energiya and IKI and French Onera. The programme is lead by the Belgian Institute for Space Aeronomy. The 220 kg spectrometer, some 2.5 m in length is scheduled to be installed on Spektr's exterior by spacewalking cosmonauts in mid-August. The assembly of the sensitive two-part optical instrument was characterised as 'the most complex operation ever carried out during EVA' by Onera engineers. (See left).

Shuttle mission STS-71 has seen the first ever link-up of an American Shuttle with the Mir complex. Almost exactly 20 years after Apollo-Soyuz, a second 'historic handshake' has ushered in a new era in space cooperation. The combined orbiter-station combination created the heaviest object ever to orbit the Earth at nearly 200 metric tons.

L. VAN DEN ABELEN, FBIS

The 'Strela' manipulator arm with a cosmonaut visible at the far end.

'VREMYA'/L. VAN DEN ABELEN



MIRAS - A Mission to Planet Earth

The Mir Infra-Red Atmospheric Spectrometer (MIRAS) was developed by the Belgian Institute for Space Aeronomy and by the French ONERA. It will operate for at least one year monitoring the composition of the atmosphere by infrared absorption spectrometry during solar occultation. Concentration profiles of at least 15 minor constituent gases of the atmosphere will be measured from the troposphere to the heterosphere. Constituents that will certainly be observed are O_3 , H_2O , CO , CO_2 , NO , NO_2 , CH_4 , N_2O , HF , HCl , HNO_3 .

The MIRAS experiment is a follow-up of previous spectrometer flights on board

The MIRAS spectrometer complete with its cover fitted.

ALCATEL



the US Space Shuttle. The spectrometer was flown on balloons in the 1970's and since adapted for use in space in Spacelab-1 (1983) and ATLAS-1 (1992). The new design for MIRAS essentially reduces the outer diameter of the instrument and splits it into two parts, the heliostat part and the telescope-monochromator-detection part. The cosmonauts can then carry the separate parts through the docking tube to the Kvant-2 module. During a scheduled five-hour EVA, the assembled instrument is installed with the help of the manipulator arm, on a set of rails that are attached to the outer part of the Spektr module.

The MIRAS results will lead to a better understanding of the interactions between solar radiation and atmospheric chemistry and dynamics. Several special observing campaigns are planned including two to study conditions at the end of the polar night in order to understand seasonal changes of ozone. A general worldwide scientific programme of observation will provide a data-base for the detection of new types of changes and perturbations that may arise from man-made sources.

THEO PIRARD, FBIS

Historic Mir Docking

An exchange of crews at Mir has been a regular feature of the space station's nearly 10-year history, but the latest exchange was one with a difference. The US Shuttle orbiter Atlantis took over the role previously fulfilled by Soyuz spacecraft in ferrying the new Mir-19 crew to the space station and returning the Mir-18 crew to Earth. Behind this difference lies the technology for the link-up of two massive structures that were independently developed by two different nations. The mission was a success for both space technology and international cooperation.

Crew Gets to Work on Spektr

The Mir-18 crew spent 3 and 4 June activating and checking out the newly arrived Spektr module, the science activities of Thagard taking a back seat to the work involved with the module.

Connections between the Mir and Spektr were made along with ventilation system and leak checks of the module. In addition, the crew began unloading Spektr and configuring it for gathering scientific measurements.

To allow enough time for unloading and setting up the Spektr module, repositioning of the Kristall module was provisionally set for 15 June. This was to be the final movement before the planned docking of the Space Shuttle Atlantis.

Operations were conducted on 5 June to switch power from Spektr's solar arrays into the main power system of the complex. During that day the second pair of Spektr's auxiliary solar array panels was to be unfurled. The Mir-18 crew subsequently sent a video recording of the deploy which showed one of the arrays not fully extended. Solar array specialists were on hand at the Kaliningrad Mission Control Center (TsUP) to view the tape and make recommendations.

On 8 June, amid concerns about the scheduled Shuttle docking, the crew tried unsuccessfully to extend the stuck solar panel on Spektr by sending pulses of power to the motor and by firing Mir's thrusters. NASA did not, however, consider the stuck panel to be "a show-stopper" for Atlantis.

Thagard Sets New Record

On 6 June Thagard became the centre of attention as he surpassed the American space flight duration record set in 1973-74 by the third, and final Skylab crew of Gerald Carr, Edward Gibson and William Pogue. The record, broken at 0628 GMT, had stood for over 21 years. One of the Skylab trio, Gibson, radioed a greeting of congratulations to Thagard who gave a press conference from the "clean, new and very beautiful" Spektr module as part of the NASA Public Affairs activities to celebrate the milestone.

Thagard noted that three months was not a long flight by Russian standards but he was happy to have had the opportunity to make the flight. He described the experience of looking out of the windows at the world below as "quite an experience" and said he thought a lot about the pos-

sibility that he might not be able to do that again after the flight.

Kristall Redock, Spektr Activated

The final redocking of the Kristall module in preparation for the arrival of STS-71 was scheduled for 9 June but in the afternoon of that day TsUP announced that the operation had been postponed for 24 hours due to low power levels on the Kristall module. Overnight, the crew installed two fresh batteries on the Kristall module to allow ample power for the redocking on 10 June. The move, as with all module relocations used the small manipulator arm built onto the module and put Kristall back on the -X front axial docking port from the -Z side port to which it had been moved for the docking of Spektr.

On 10 June Thagard activated the American components inside the Spektr module including the thermal electric holding facility and the thermoelectric freezer. Both are freezers to hold biological samples collected during the metabolic sessions.

The agency reported that the module had been re-docked that day from the -Z to the -X port in an operation lasting about an hour.

On 12 June Thagard transferred previously collected urine, saliva and blood samples to TEHOF, the US freezer on Spektr. Checks of the hardware located in Spektr had already begun and the centrifuge in Spektr was spun up for a checkout and reported by NASA to be functioning normally.

NASA and RSA officials held telephone discussions on 13 June to assess the status of the plans to launch Atlantis on 22 June. Chief concern was the status of the problems to be addressed during the unscheduled EVA on 16 June to examine the Spektr solar array. There was also concern that delay could mean three orbiters in the VAB, which was designed for only two, which would cause a problem in the event of a hurricane passing through the area. Meanwhile the "Hurricanes" in orbit - the Mir 18 crew - were given a series of tasks to perform during their planned 5-hour EVA. These included inspection and repair of a solar array on the Kvant 2 module which was failing to track the sun correctly; inspection of the -Z port seal, even though NASA had reported that the leak had stopped, and retrieval of an unspecified science experi-

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The Mir-18 crew patch includes a depiction of the Space Shuttle docking with the Mir Space Station above Earth. The surnames of the crew members - Strekalov (Gennadiy M., flight engineer); Dezhurov (Vladimir N., mission commander); and Thagard (Norman E., cosmonaut researcher) are written with Cyrillic characters. NASA

ment (possibly the American "Trek" cosmic ray detector which had been outside the station for two years longer than anticipated because mission planners had not allocated the 20 minutes required for its retrieval in any EVA since).

Late on 15 June TsUP announced that the EVA had been cancelled. NASA said in a statement that the cancellation was because TsUP had decided that more time was needed to refine plans for the spacewalk and that discussions were underway to determine any impact the partially deployed Spektr solar array would have on the joint mission.

Preparations in Moscow and on Mir

With the cancellation of the EVA, NASA released a statement announcing that the launch of STS-71 was scheduled for 23 June, the window being 7 minutes. Atlantis would dock with the Mir station on 26 June, undock on 1 July and return to the Kennedy Space Centre on 4 July.

During 20 June, a small team of NASA flight controllers and mission managers began to arrive at TsUP for the STS-71 mission. A team of Houston flight controllers would be working in three rooms adjacent to the Russian main flight control room, serving as consultants on Shuttle orbiter systems for Russian flight controllers and as liaisons for the NASA control team in Texas. The team, headed by veteran Flight Director Bill Reeves, included a flight planning expert, environmental systems experts and safety experts. A similar team of Russian flight controllers was located in Houston for the mission as well. The flight control team joined the science operations team that had been in Russia since the beginning of the Mir-18 flight.

On Mir the cosmonauts were performing several end-of-mission countermeasures to prepare their bodies for the return to Earth's gravity. The measures focussed on their cardiovascular system, using a holter monitor strapped to the American's torso, as well as the body's muscles and

bones with the three crewmen exercising twice a day and spending additional time in the Chibis suit.

Thagard was also conducting a number of experiments to help investigators characterise the microbial environment on Mir. These experiments were scheduled late in the Mir-18 mission so that the samples would remain viable until they were returned to Houston.

NASA said that, for the next several days, until Atlantis arrived to take the Mir-18 crew home, Thagard would continue checking out equipment in the Spektr module for experiments to be conducted on Mir during future missions. ITAR-TASS also added that measurements of the radiation levels in the complex and the spectra of ionised cosmic radiation were underway.

Launch Delays

As NASA began the countdown to the launch of Atlantis at the T-43 hour mark meteorologists were forecasting a 70% chance of bad weather on 23 June which would ground the vehicle. The primary concerns were thunderstorms.

Preparations began to retract the rotating service structure (RSS) to launch position, an activity scheduled for late evening on 22 June. The meteorologists were now forecasting an 80% chance of poor weather for the next day.

As the astronauts slept that evening the Kennedy Space Center environs were enveloped in thunderstorms and lashing rain and NASA delayed a decision to begin loading the 500,000 gallons of cryogenic propellants. There were lightning strikes within five miles of the launch pad.

After delaying for over two hours, with no sign of clearer weather on the horizon, a decision was taken to scrub the launch for that day and reschedule for 24 June with a 10 minute launch window. The weather forecast for 24 June, however, gave a 70% chance of another delay.

However, the omens for another scrub on 24 June were present when, just before the crew were set to leave for the

bus to ferry them to the launch pad, lightning struck the pad's conducting mast. There was no damage at the pad but by the time the crew was strapped into Atlantis and waiting for the launch the rain was so bad that reporters at the press site some five km from the launch pad could not see the shuttle.

The decision to scrub for the day was taken around 45 minutes prior to the scheduled launch time and NASA announced that a decision would be taken on Monday 26 June on whether to attempt a launch on 27 June during a 10 minute window.

Meteorologists however predicted a 20% chance of launching on the afternoon of 27 June due to the persistent thunderstorms, thick cloud and showers.

Before the third planned launch attempt of the Atlantis orbiter, the cosmonauts aboard Mir undertook the Resonance experiment to measure the vibration and other characteristics of the Mir complex. The Resonance experiment is a standard series of tests performed after each new module addition, dating back to Salyut 6, and involves the cosmonauts making vibrations in various areas of the complex by jumping up and down so that these vibrations can be monitored. The Americans had provided sophisticated acceleration monitors for this experiment.

Third Launch Attempt Succeeds

NASA announced immediately after the 24 June scrub that the next attempt to launch Atlantis, weather permitting, would be on 27 June at 1932 GMT with a window of 10 minutes. There was concern that the predicted weather outlook - 70% probability of a violation of launch commit criteria - would actually worsen as the week wore on.

An on-time launch would lead to a docking with Mir on Flight Day Three but a launch in the final three minutes of the window would result in a Flight Day Four docking with Mir.

On 26 June the cryogenic reactants, which service the orbiter's fuel cells were topped up and the orbiter's mid-body umbilical unit was again demated from the orbiter and retracted into the fixed service structure. Late in the evening the Rotating Service Structure was rolled back and the loading of the liquid oxygen and liquid hydrogen fuels into the external tanks was scheduled to begin at around 1015 GMT (0615 local time). The astronauts and cosmonauts meanwhile went through a series of briefings on the weather at KSC and their TAL sites in Spain and Africa as well as changes to their flight plan.

Tuesday, 27 June began early for Atlantis' crew of five Americans - "Hoot" Gibson, Charlie Precourt, Bonnie Dunbar, Greg Harbaugh and Ellen Baker - and two Russians - Anatoli Soloyov and Nikolai Budarin - with a pre-launch breakfast. The seven member crew then departed for the launch site on the Astrobus following the traditional walk-out.

In contrast to their earlier journey to the pad, three days before, this time the weather forecasters were predicting a 60% chance of good weather for the 10 minute launch window. Although weather at KSC was hot and very humid the thun-



Mir-19 commander Anatoly Solov'yev at the Kennedy Space Center. The other Mir-19 crew member, Nikolai Budarin, was also taken to Mir in Atlantis.

PETER GUALTIERI, WEST KENTUCKY NEWS

derstorms were held at bay by a fog which hung over the site until late morning and stopped the atmosphere heating up. Therefore, the weather was never a real factor in the 27 June launch attempt. The automated sequence to the launch was handed over at T-31 seconds and, on schedule, ignited the liquid-fuelled main engines of Atlantis. Once the computers had detected the nominal operation of the three main engines they issued commands for the ignition of the two massive solid fuelled strap-on boosters.

Atlantis roared off the pad at exactly 1932:19.044 GMT heralding:

- The 19th Mir crew on its way to the orbital outpost;
- The first Shuttle/Mir docking mission,
- The 100th American crewed space mission
- The beginning of the international space station programme.

The launch was watched by thousands of people at KSC and the environs including a delegation from Russia's RKK Energia, the owner and operator of the Mir station. The delegation, including its head Yuri Semenov and recently-returned cosmonaut Yelena Kondakova, had stayed in Florida following the 24 June scrub even though they had been scheduled to fly back to Russia the day after.

Just over 8 minutes after ignition Atlantis discarded the external fuel tank, inserting the craft into Earth orbit, and about 45 minutes after launch Gibson commanded the two Orbital Manoeuvring Systems jets on the orbiter to fire for 45 seconds (the shortest OMS burn in the shuttle programme to date) to place Atlantis into an orbit of 292 x 157 km, representing the lowest orbit ever for an American spacecraft.

Approaching Mir

At the time of the Atlantis launch Mir was over Iraq and the low orbit enabled the orbiter to close the 13,000 km gap between them rapidly at first, at a rate of about 1630 km per orbit.

Three hours and thirty-nine minutes after launch, Atlantis conducted the NC-1 burn, firing both Orbital Manoeuvring Sys-

One of Kristall's retractable solar panels. SPACEVIEW, AMSTERDAM



MIR MISSION REPORT

tem engines for just over two minutes to raise its orbit to an altitude of 389 x 293 km, so slowing its closing rate on Mir to 520 km per orbit.

The crew woke at 0832 GMT to begin their second day in orbit and at 1048 GMT, Gibson fired Atlantis' OMS engines for 14 seconds, slowing Atlantis' closing rate on Mir and precisely aligning the orbiter's ground track with that of the complex.

The burn placed Atlantis in a 390 x 300 km orbit, closing on Mir at a rate of 463 km per orbit. At 1000 GMT, Atlantis trailed Mir by about 5558 km closing the distance between the two spacecraft at a rate of 510 km per orbit.

Shuttle equipment to be used for the rendezvous and docking was checked and found in good order, although batteries were missing for the handheld laser ranging device. NASA said that the handheld device was not needed for rendezvous and served only as a supplement and backup for range information, however, the crew could plug the unit directly into the shuttle's power supply to circumvent the missing batteries.

The Russian-designed docking ring that would first contact the identical one on Kristall was extended to its proper position for docking and the mechanism was found to be in excellent condition.

Aboard Mir the cosmonauts continued exercising and taking an inventory of all the life-support systems of the complex to pass onto Solovyov and Budarin. They continued to pack up the results of their experiments and prepare their samples

for the return on Atlantis.

Shortly before 0800 GMT on the third day, Atlantis' OMS engines were fired for 45 seconds. That burn, known as NC-4, raised the perigee of Atlantis' orbit and positioned the shuttle roughly 15 km behind Mir. One orbit later, at about 0930 GMT, Commander "Hoot" Gibson was scheduled to again fire the jets for the terminal initiation (TI) burn which began the final phase of the rendezvous. The burn put Atlantis in position to intercept Mir from a point directly below the complex, on an imaginary line called the R-Bar or Earth radius vector at about 1115 GMT.

Atlantis' first sighting of Mir was at a distance of about 65 km. Bonnie Dunbar was heard to say to Norman Thagard via the VHF radio "we have you in sight".

At about 1040 GMT Mir was manoeuvred in attitude to accept the Atlantis docking approach and the solar arrays on Mir were commanded to an "edge on" attitude relative to Atlantis' approach so that they would not be contaminated or damaged by plumes from Atlantis' steering jets. Completion of these two tasks was vital before docking operations could proceed.

As Atlantis closed, the orbiter's rendezvous radar system began tracking Mir and providing range and closing rate information to the Shuttle crew. The Trajectory Control Sensor, a laser ranging device mounted in the payload bay, supplemented the orbiter's onboard navigation information by supplying additional data on the range and closing rate.

As Atlantis closed the final 15 km, there were opportunities for four small successive engine firings to fine-tune its approach using its onboard navigation information. Firings were performed in the so-called "Low-Z" using jets on the nose and tail of the orbiter which were slightly offset to avoid firing directly at Mir.

Approaching along the R-Bar, from directly underneath the Mir, allowed natural forces to brake the approach more than would occur along a standard Shuttle approach from directly in front of Mir.

The manual phase of the rendezvous began as Atlantis reached a point about 800 m below Mir when Gibson took the controls on the aft flight deck.

Video shots from the Kvant-2 module provided an oblique view of the approach in which both the orbiter and the Kristall module's docking collar could be seen. Mir's thrusters and gyros were disabled for the final approach to put the station into a "free drift" mode.

The "go" for approach and docking was relayed at 1223 GMT and Gibson commanded the orbiter to close in on the complex approaching at a rate of 0.1 feet per second. At 1255 GMT the final approval for docking was given and Gibson began inching the orbiter towards the historic docking.

During the approach Gibson had to keep Atlantis inside an ever narrowing imaginary cone. At a distance of just 4 feet from the Kristall docking system he had to be within 3 inches of the centre of this cone.

Docking Success

The TV camera in Atlantis shook when the two docking units touched right on schedule at 1300 GMT as the orbiter and station passed 395 km over Lake Baikal in the Russian Far East.

"Houston, we have capture," Gibson radioed. "Podtverzhdayu zakhvat, (I confirm capture)" Dezhurov radioed to TsUP.

At TsUP there were extraordinary scenes as NASA administrator Dan Goldin leapt up and hugged the giant head of the Russian Space Agency Yuri Koptev. The whole of the TsUP burst into applause.

In later interviews Thagard described the physical sensation of the Atlantis contact. He said that when the Progress M cargo craft docked on 12 April he had been within a third of a metre of the actual contact but heard and felt nothing. When Spektr docked on 1 June there was very little sensation; but when Atlantis touched "we felt it," he said. "One hundred tons hitting the station had some impact on us, and it was pretty impressive compared to the mild sensation we had with the previous vehicles."

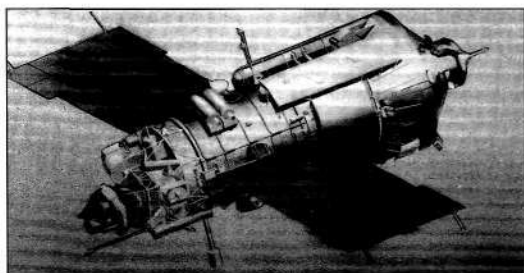
Gibson was later to say that there were no bangs or other sounds audible on Atlantis and there was no sensation. With the docking hatch sealed air was pumped into the Orbiter Docking System (ODS) and the crew of Atlantis began to equalise pressures in the airlock of the ODS and in Mir to allow the historic handshake and crew swap to begin.

Handshake in Orbit

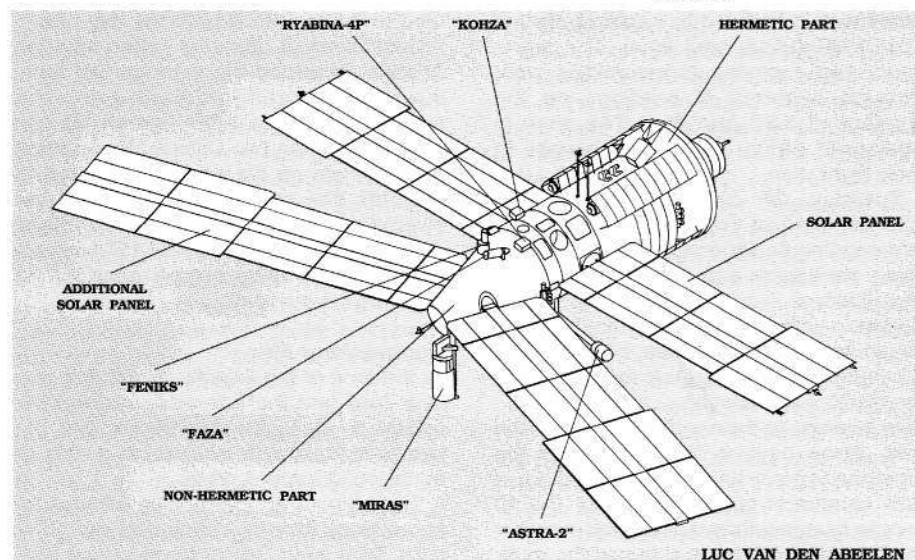
Over the next orbit the crews of Atlantis and Mir prepared for the expected emo-

Mir's New Module

The Spektr module docked with Mir on 1 June to provide much needed auxiliary power and a number of scientific experimental packages for spectral measurements such as the MIRAS spectrometer.



Th.P./SIC



tional meeting. There had been much speculation as to what would be said at the historic moment of meeting and even where the handshake would take place - inside the Kristall or on the threshold of the two docking units.

As Gibson was given a "go" to open the hatch of the ODS he could see Dezhurov through the small porthole smiling.

The hatch was removed and Gibson waited at the threshold. Dezhurov was in the docking unit of the Kristall with a camcorder (it seemed that everyone on the two craft had a camcorder or a still camera and there were repeated flashes as still photos were taken).

There was chatter in both Russian and English before Norman Thagard cried out "Hey, you're upside down!" to Gibson and his crew.

Finally Dezhurov approached the threshold and, saying "come on through...", firmly clasped the hand of Gibson just over 2 hours after the docking.

The 10 spacefarers, instantly the largest crew in a single space complex, gathered in the Mir base block in front of the hatch to the Kvant astrophysics module and faced the cameras to all wave and make for a truly historic picture.

With the formal greetings out of the way, Atlantis' crew completed a transfer of responsibilities for the station from the three Mir-18 crew members to the two Mir-19 crewmen. Following a transfer of personal gear and a changeout of the individual, custom-made foam seat liners in the Soyuz TM-21 descent cabin, Mir-19 Commander Anatoly Solovyev and Flight Engineer Nikolai Budarin officially assumed duties on the station. Solovyev and Budarin were to sleep aboard the Mir from that night while astronaut Norman Thagard and cosmonauts Vladimir Dezhurov and Gennady Strekalov, aboard Mir for the past 105 days, slept aboard Atlantis.

The final words of the day were from Gibson. He radioed that the crews "had a terrific day today....We started out running and we ran all day long and it certainly was worth it."

Ceremonials in Spacelab

Early on the morning of 30 June the two crews met in Spacelab for a ceremonial gift exchange commemorating this flight. During the ceremony the crew members joined halved pewter medallions bearing the impression of a docked shuttle and Mir. The ceremonies were intended to commemorate those conducted on the 1975 ASTP mission and also included the joining of four scale models of Atlantis/Mir which would be returned to Earth and one each given to the Presidents of America and Russian, Clinton and Yeltsin, and the heads of NASA and the RSA, Goldin and Koptev.

A proclamation was also signed declaring the event had happened, marking the date, time and place of the signature and there were several smaller gift exchanges. For example Gibson presented Dezhurov with two sets of strings for the guitar held aboard the Mir station to replace those which by now had worn out.



On their return to Earth in Atlantis, Strekalov, Dezhurov and Thagard utilised Recumbent Seating System (RSS) hardware following their long-duration stay in space. The photo shows a ground test and checkout of the equipment at the Johnson Space Center by astronauts Kenneth S. Reightler Jr. (foreground) and William M. Shepherd. The hardware was flown in Atlantis on STS-66 when ESA mission specialist Jean-Francois Clervoy checked the fitting arrangements (*Spaceflight*, March 1995, p.103).

NASA

Joint Flight Experiments

For the period of the joint flight the 10 crew members were to conduct 15 separate biomedical investigations into how the human body functions in a microgravity environment.

The investigations would be conducted in the Spacelab module. Seven different disciplines were represented including cardiovascular and pulmonary functions in weightlessness, human metabolism, neuroscience, hygiene, sanitation and radiation, and behavioural performance and biology. The studies begun during the Mir-18/STS-71 mission are to continue for several years as part of the continuing Shuttle-Mir Science Program.

Cosmonauts Dezhurov, Strekalov and Thagard were to be thoroughly examined using the Spacelab treadmill and the negative pressure suit as well as having their bodily fluids drawn for later examination.

The rationale behind the NASA medical experiments was to evaluate the men's condition in weightlessness before the return to Earth where some of the more subtle effects of exposure to weightlessness are lost during the first few minutes back at 1g. The men were being examined by Doctors Bonnie Dunbar and Ellen Baker. Whilst Dunbar was probably the best Russian speaker amongst the shuttle crew (with the probable exception of Thagard), Baker had learned several phrases, such as "give me your arm and I'll take some blood" and "this will take 3 minutes", so that she could converse with Dezhurov and Strekalov to tell them what she wanted them to do.

In addition to supporting the medical and scientific investigations, crew members began the transfer of equipment, hardware and experiment specimens from the Mir module to Atlantis for return to Earth.

The Atlantis crew delivered some 200 kg of food, clothing and science equipment, 170 kg of water and 50 kg of fresh air.

Medical samples and other materials associated with the Mir-18 crew members were loaded into Atlantis for the trip home. Equipment for the Mir-19 and future missions was transferred from the shuttle to the station.

Along with the Mir-19 equipment, Atlantis' crew also filled four Russian space agency tanks with excess water from the shuttle and transported it to Mir.

1 July

In the morning the hatches between the two spacecraft were closed for about three hours while the orbiter used its steering jets to change the station's attitude. The jet firings were part of a test to study the performance of the docking mechanism and tunnel adapter during orbital manoeuvres, and to see how they would affect the station's solar arrays. NASA reported that the tests showed the docking mechanism to be secure.

After the test was complete, the hatches were reopened and the transfer of items between Mir and Atlantis resumed. Included amongst the day's transfers were specially designed spacewalking tools to be used by the Mir-19 cosmonauts in mid-July to free the jammed solar array on the Spektr module.

Thagard had lost about 6 kg during the mission which one NASA spokesperson blamed on water loss, common on long flights, and the quality of the dehydrated Russian food.

2 July

The crew quickly began another busy day of scientific and medical investigations in the Spacelab module. The day's investigations were to focus primarily on

MIR MISSION REPORT

understanding how the cardiovascular system responds to microgravity.

The cosmonauts also continued their scheduled exercise sessions designed to help minimize their readaptation to Earth's one-gravity environment. Dezhurov, Strekalov and Thagard walked or ran on the treadmill, rode the bicycle ergometer, or performed resistive exercises for 1-2 hours every day.

In parallel with the joint medical investigations, remaining crew members continued the transfer, packaging and storage of equipment to be returned to Earth on board Atlantis. Transfer of excess water from Atlantis to Mir also continued throughout the day.

Inside the space station Solovyev and Budarin donned and conducted leak checks to the Sokol launch and entry suits they were to wear on July 4 when they manned the Soyuz and flew away from Mir to document the undocking of the American shuttle.

During the period of joint flight controllers had noticed that Atlantis was using about 70% more fuel than planned to keep the complex in a "solar inertial" attitude so that the Mir arrays faced the Sun to generate electricity badly needed by the station. Determining the problem to be excess firings of the orbiter engines to keep the complex within 5 degrees of attitude, managers agreed that the complex should not be kept in the "solar inertial" attitude as much as was planned pre-flight.

3 July

On the final day of the joint mission in which crews would swap between the Shuttle and the Mir station the crews were soon conducting yet more joint US and Russian biomedical investigations in the Spacelab module.

The shuttle astronauts used the electronic still camera to downlink images of the jammed solar array on Mir's Spektr module. The array failed to deploy properly when one of the latches that held it in place for launch failed to release. The photos, close-ups of the latch, were to be used by Russian engineers to refine plans for an EVA by Solovyev and Budarin to cut the array free.

Prior to departure from each other the ten cosmonauts and astronauts held a formal farewell ceremony in the Mir base block.

Later, with a final hug to Strekalov, Solovyev bolted the hatch of the Kristall module. Atlantis' Flight Engineer Greg Harbaugh followed suit shortly afterward, performing a final check on a docking target the STS-74 crew will use and then closed the ODS hatch door. Mir's hatch was closed at 1932 GMT, and Atlantis' hatch was closed at 1948 GMT. Following the hatch closing, Harbaugh began depressurizing the tunnel that had connected Mir and Atlantis, venting the air overboard to equalize the tunnel with the vacuum of space in preparation for the following day's undocking. By the time of the scheduled undocking more than 1/2 tonne of water, 25 kg of oxygen, and 36 kg of nitrogen had been transferred to the space station. The oxygen and nitrogen was transferred to Mir by using the Shuttle's atmospheric system to raise the

air pressure in the station.

Undocking and Separation

On 4 July Solovyev undocked the Soyuz craft at 1054 GMT and began to manoeuvre it to a position about 100 m away from the complex so that he could see the Atlantis/Mir combination side-on.

Gibson cut the links between Mir and Atlantis at 1110 GMT by releasing the latches that held the craft together and allowing pre-loaded springs to push the two apart.

The separation was filmed by Budarin in Soyuz and video of the event was relayed to Earth later in the day following the early Soyuz re-docking with the Kvant port due to a computer failure on the station which caused the station to drift and threaten to become unstable.

Atlantis then flew a slow circuit around the station to allow the astronauts to document the complex in preparation for future visits.

5 July

By next day Atlantis and Mir were separating by around 17 km per orbit. Even with 370 km between the two craft, Gibson reported he could still clearly see the station as a distant star with each sunrise.

6 July

On 6 July the penultimate day of their flight, Gibson, Precourt and Harbaugh powered on one of Atlantis' hydraulic systems and cycled the flight control surfaces to be used during reentry. They also fired the orbiter's reaction control system jets in the traditional preflight checkout of the Shuttle's systems prior to the scheduled landing.

Dunbar and Baker erected the special reclining seats in the mid-deck of Atlantis where the Mir 18 crew would be located during the reentry and landing.

7 July

With the weather at KSC under close scrutiny the Atlantis crew began preparations for their return to Earth around 1000 GMT. The airlock connecting the crew compartment to the ODS and Spacelab was closed. The timeline had the crew aiming for a first deorbit burn attempt at 1345 GMT with a second opportunity one orbit later. Atlantis was orbiting the Earth at an altitude of 400 km by 385 km when the "go" for deorbit was received. The weather at KSC, with clouds bubbling up around the centre would be acceptable.

Gibson and Precourt steered the orbiter to a flawless landing at 1454 GMT after completing 154 orbits of Earth. The main gear touchdown occurred at 1454:36 with the nose gear touching the runway 8 seconds later. The orbiter

'Objects on the Moon' Competition Winners

Winners to whom video prizes will shortly be dispatched are:

G. Buckley	Lancs
R. Fox	Midlothian
R. Ward	Sheffield

The correct answers are: 1. C; 2. B; 3. A.

stopped forward motion at 1455:27 to effusive praise from Houston, recognising the importance of the first Shuttle/Mir docking mission.

The flight had lasted 9 days, 19 hours and 23 minutes.

The assistance of Luc van den Abeelen with illustrative items is gratefully acknowledged.

Spaceflight, next issue

- More about the STS-71/Mir mission when *Neville Kidger* will provide details of the all-important medical programme and the surprising psychological revelations of Norman Thagard.
- More about 'Space at the Paris Air Show' will be provided by *Theo Pirard* following *Clive Simpson's* report highlighting the UK Space presence that appears on the opposite page.
- Plus *Spaceflight's* range of regular features and information.

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The British Interplanetary Society
SPACELINE

SPACEFLIGHT, Vol. 37, August 1995

UK Space in Evidence at Paris

A full-scale model of Europe's new Ariane rocket dominated the Le Bourget skyline at the Paris Air Show this June, writes *Clive Simpson*.

The new launcher, scheduled to blast off on its maiden mission from the launch site in French Guiana at the beginning of next year, was also the subject of a major order placed at the show by Arianespace. European space industry will prepare the first batch of 14 Ariane 5 rockets in a contract that is worth more than 15 billion French francs in total. After a series of test launches the first of these rockets will be used commercially towards the end of 1996 and the launch rate will gradually increase to five per

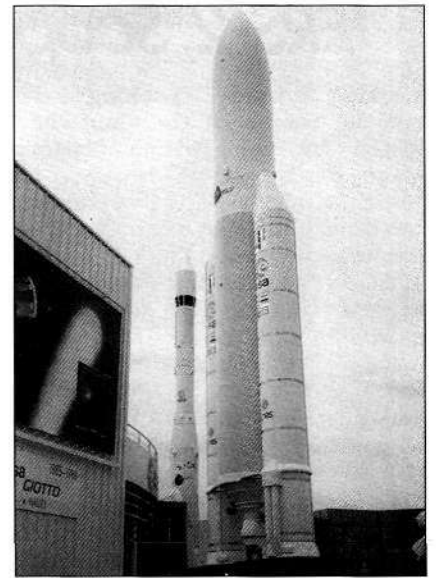
year by the year 2000.

Thousands of visitors to Le Bourget this year were able to get a first hand impression of Ariane 5, standing right at the base of the mighty rocket engines and gazing upwards to the payload fairing which will be capable of accommodating two large communications satellites. But Britain's meagre support in recent years for this new commercial venture is still reflected in the absence of the Union Jack among the flags of 12 other countries displayed on the twin boosters on either side of the main vehicle.

Other British space activities, however, were more in evidence at the Air Show this year. The British National Space Centre (BNSC) coordinated a stand with the UK space industry (the United Kingdom Industrial Space Committee) and Rutherford Appleton Laboratory.

Space Minister Ian Taylor, MP spent two days in Paris for a series of meetings with industry and his counterparts from other member states, preparing groundwork for the ESA ministerial conference this autumn.

Alan Hicks, UKISC secretary general, said the impetus for a stand at Paris came from the success of last year's Farnborough display. "As well as the space minister we had a number of major visitors, including members of the Parliamentary Space Committee and industrial representatives. As part of the UK presence they also had discussions with



Ariane 5 at le Bourget. CLIVE SIMPSON

ESA directors and the European Commission," he added.

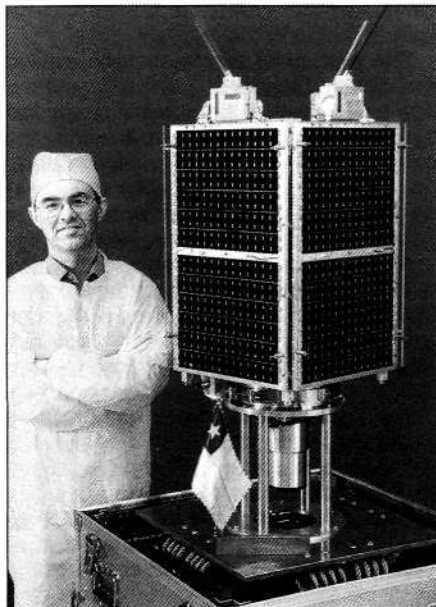
British representatives took over the hospitality area of the ESA pavilion for an evening towards the end of the week for a reception at which space minister Ian Taylor reinforced industry's position, paying tribute to the fact that it had increased turnover by 34 per cent in two years. "I commend the UK space industry for the strong and increasingly important contribution it is making to Britain's economy", he said. "The industry is playing an innovative role in Europe in both space technology and in the practical use of data from observation satellites."

Awards for Surrey Satellite Pioneer

Professor Martin Sweeting, Managing Director of Surrey Satellite Technology Limited (SSTL) has been honoured with two awards: an OBE in the Queen's Birthday Honours List and a Royal Academy of Engineering Silver Medal. The OBE is in recognition of his services to Space Satellite Techniques and the silver medal for an outstanding personal contribution to British engineering. Professor Sweeting, who has pioneered the worldwide movement towards smaller, faster, cheaper satellite missions, said, "It is gratifying for me and for my team to be recognised by these two prestigious awards".

SSTL, with 12 satellites to its credit, now leads the world in small satellite engineering and has grown in spite of the worldwide reduction in space budgets. As to the future, Professor Sweeting hopes to place an SSTL satellite in orbit around the Moon by the end of the century. He says, "There is no practical reason why Britain cannot mount an inexpensive, scientifically-meaningful lunar mission".

Professor Martin Sweeting stands beside the latest microsatellite, FASat-Alfa, designed and built for the Chilean Air Force, which is due to be launched in August. It will conduct a variety of space experiments which include the monitoring of the ozone layer over Chile and the sending of information to schools in Chile to encourage space studies. SSTL



New Position for ESA Astronaut

Dr Wubbo J. Ockels (49) from the Netherlands recently announced his retirement as an active astronaut having logged 168 hrs, 44 mins and 51 secs in space.

Dr Ockels has been appointed senior technical assistant in the Automation and Informatics Department at ESTEC, the Research and Technology Centre of the European Space Agency at Noordwijk. He will be responsible for research and studies on robotics, telescience, telepresence, virtual reality, and so on.

Dr Ockels, who already was a professor at the Technical University Delft, will be engaged also in projects with "young graduates" and other students at ESTEC.

In 1978 he was selected as a candidate payload specialist for Spacelab-1 together with Ulf Merbold and Claude Nicollier. Because of delays in the Shuttle programme there was an opportunity for the ESA candidates to participate in NASA astronaut training. Wubbo Ockels and Claude Nicollier were accepted in 1980 by NASA as members of Astronaut Group IX. As the first non-American astronaut candidates, they successfully completed their mission specialist training in 1981.

Dr Ockels served as alternate payload specialist for Ulf Merbold on Shuttle mission STS-9/Spacelab-1 in 1983.

In October and November 1985, Dr Ockels made his only space flight as a payload specialist on STS-61A/Spacelab D-1. During this highly successful mission (the only shuttle flight with eight crew members until STS-71) the astronauts per-

formed life sciences and material processing experiments sponsored by the Federal German Aerospace Research Establishment (DFVLR) using various ESA-developed facilities. ROLF SCHOEVAART

Dr Wubbo Ockels crawls into his unique self-developed sleeping restraint during the STS-61A/Spacelab D-1 mission. NASA



ERS-2 Scope for UK Firms

"Looking forward ... Looking down" was the theme of the Conference hosted by the British National Space Centre on 9 June at the Queen Elizabeth II Hall overlooking the Houses of Parliament in Westminster, London. The first combined visible/infrared images received from the UK ATSR-2 instrument onboard the newly-launched European remote sensing satellite ERS-2 were shown to an invited audience of industrial and commercial delegates. *Spaceflight's* correspondent, Philip C. James, reports.

Ian Taylor MBE MP, Parliamentary Under-Secretary of State with special responsibility for Space at the UK Department of Trade & Industry, welcomed the delegates who included executives from commercial sectors not normally associated with the space industry. This, he believed, underlined both the relevance of remote sensing satellite data to ordinary commercial life in the UK and the business opportunities for companies offering information services derived from such data. The Along-Track-Scanning-Radiometer, ATSR-2, was itself a product of collaboration between UK commerce and academia, notably Matra Marconi Space and the Rutherford Appleton Laboratory (RAL).

The second speaker, Prof. Mike Cruise of RAL, outlined the benefits offered by ATSR-2 to the atmospheric and oceanographic science communities. But applied research had not been neglected in designing the instrument which could bring near-term benefits by mapping the thermal output of cities and detecting forest-fires at night whereas its ability to detect ice-laden clouds and volcanic dust aerosols was plainly of interest to aviation authorities.

The third speaker Dr. David Sloggett, deputy chairman of Cray Systems Ltd presented a commercial perspective on the partnership between government, academic and business institutions. In his opinion, pretty images were useful only for hanging on the wall. The secret of commercial success in remote sensing lay in identifying the key data for any application; extracting it from the mass of otherwise irrelevant ground clutter and presenting the resulting information to commercial customers in a form relevant to the operation of their businesses. Under current per-image pricing schedules, discarding most of the data in a scene caused information prices to appear very expensive. Dr. Sloggett urged the data providers to adopt more flexible bulk-data provision agreements.

Commercial applications of satellite remote sensing data were in evidence at an exhibition set up adjacent to the conference hall. Eight exhibits included a sugar-beet production prediction system developed by Logica and British

Sugar and marine oil and gas exploration applications demonstrated by Satellite Observing Systems (SOS).

Dr. Chris Mutlow, Project Scientist at the RAL expanded on the importance of the global coverage offered by satellite observation in identifying inter-dependencies between wave, wind and weather. Subtle long-term climate changes require frequent observations of low systematic error and exceptional stability over many years. That ATSR-2 meets these goals is due largely to careful design of the instrument and the use of dual observations, slanting and vertical, of the same areas along the ground-track of the satellite. The lessons learned in building and operating ATSR-1 on ERS-1 contributed to improvements in the design of this second instrument, a trend to be continued with the third ATSR sensor, projected for flight on ENVISAT. Dr. Mutlow believes this continuity of observation will cut significantly the time required to resolve important issues such as the existence of global warming.

Closing the meeting, Prof. Cruise presented the Minister with a framed ATSR-2 image of the United Kingdom.

PHILIP C. JAMES

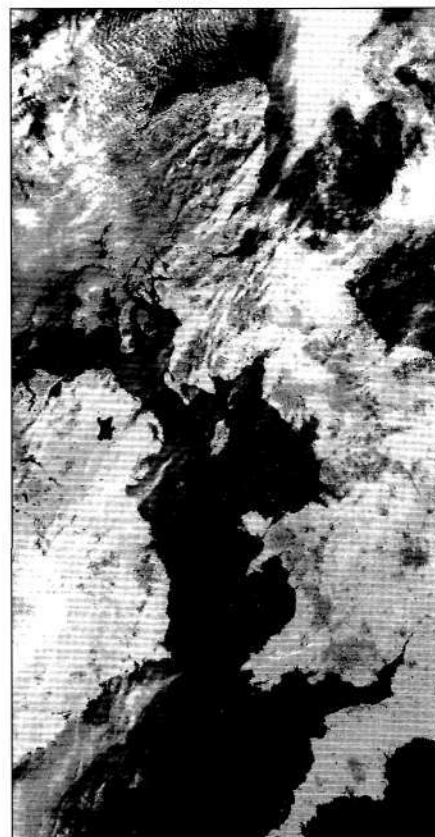
BIS News

IAF Congress, 2001 BIS Proposes UK Venue

In 2001 the International Astronautical Federation will be celebrating the 50th anniversary of its foundation at the 1951 Congress in London. The Society was at the centre of these events of 50 years ago, both in helping to draw up the IAF constitution and as the host society of the London meeting.

It is therefore appropriate that the Society, as the UK representative member of the IAF, should be seeking to host the IAF Congress of 2001 and, to this end, it has made a bid to the IAF to be invited to do so. Its application will come up for consideration at this year's IAF Congress in October at Oslo and the Society is making every effort to ensure its success. The anniversary will be a landmark in international space affairs, the events of 50 years ago being justifiably seen as 'a great step for mankind'. Members can indeed feel proud of the part played by the BIS in ensuring that such a step was taken and in such a bold and enduring way.

The Society has been host of two other IAF Congresses in the UK, namely those of 1959 in London and 1987 in Brighton, Sussex, England, the latter being attended by over 1500 participants. If present plans go ahead, the 2001 Congress will be held in Glasgow, Scotland where excellent facilities can be provided for the large international participation that the event can be expected to attract.



Britain and Ireland - view from ATSR-2.

ESA/RAL/BNSC/NERC

Soviet/CIS Astronautics

Technical Symposium of the Society, 3 June 1995

This meeting which has met annually since 1980 has become one of the foremost forums for discussing the history and purpose of Soviet-Russian Cosmonautics. It attracted participants from America, Belgium, Holland, the Republic of Ireland as well as the UK.

The theme of looking at the N-1 booster was one of the highlights of the day. Barry Sanders presented his work analysing the trajectory and the performance of the N-1 lunar launch vehicle. This was followed by the showing of a number of films on the lunar programme.

Presentations included a paper by Brian Harvey on the development of the new Russian Cosmodrome at Svobodny. Dave Shayler reviewed Soviet Stratosphere flights in the 1930s.

The politics of the aerospace design bureaux and manned space policy of the 50s and 60s was the subject presented by William Barry. This was followed by the chair reading a paper submitted by James Oberg (see p.254). Also shown were some slides from his recent visits to space facilities in the old Soviet Union.

Phil Clark did two presentations during the day. Initially he looked at the Kosmos 2290 mission and its purpose. Also he presented a paper on the work and history of the Yuzhnoye Production Association. The Symposium also gave opportunities for participants to talk together and exchange information.

The smooth running of the day was due to the efficient help of the BIS staff. The Symposium was chaired by Rex Hall. Anyone wishing to present a paper at next year's symposium can send details to the chair c/o the BIS.

REX HALL



Lunokhod-3

Sir, During a recent visit to the Lavochkin Scientific-Production Association near Moscow I was offered an opportunity to have a look at their museum. I was shown the original Luna capsules which returned from the Moon with lunar soil and copies of most of the craft that flew to the Moon, Venus, Mars and Halley's Comet.

One Lunokhod lunar rover drew my special attention, because it was a bit different from Lunokhod-1 and 2 which were delivered to the Moon in the early seventies. Then the director of the museum told me that this was not a model, but Lunokhod-3 originally destined to fly to the Moon as a successor to the previous two models. The most apparent difference was in the television cameras up front. Lunokhod-1 had two fixed television cameras, Lunokhod-2 had three of them, two side by side and one above those, to be able to look further ahead. But this Lunokhod had a tiltable platform with two cameras, that would have facilitated navigation by the Earthbound crew.

Missing from Lunokhod-3 was the French laser reflector, present on the earlier two Lunokhods. The director told me that, with two reflectors already on the Moon, it was not worthwhile carrying a third one.

The second Lunokhod flew to the Moon in January 1973. In 1976 the Soviets decided to stop their lunar programme entirely and the launch of a third Lunokhod was cancelled. So now it spends its days quietly in the Lavochkin museum.

PETER SMOLDERS, FBIS
The Netherlands

Weightlessness Experienced

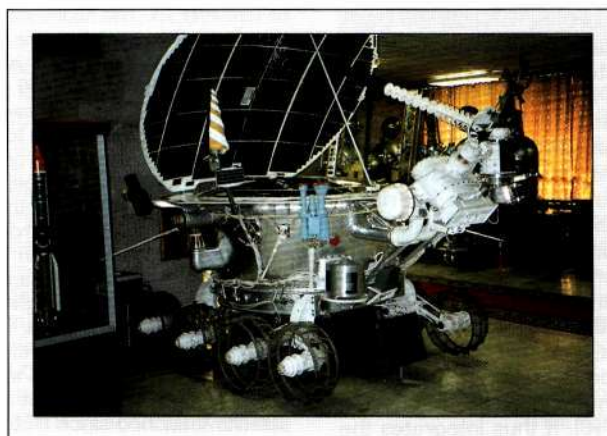
Sir, I draw comic strips on space for a Belgian comic strip magazine, AURACAN, and the European Space Agency gave me the opportunity on 25 April to make a number of parabolic flights on board the CNES/DGA "Zero-G" aircraft to help me in my job. Everything that I did and saw will be useful in giving me inspiration and ideas.

Weightlessness is a wonderful sensation. It is fantastic to fly like an astronaut in space and for me it was like a dream come true. I was fascinated to see objects floating near me and to observe water change into a bubble.

We made 31 parabolas (equal to 11 minutes and 15 seconds of weightlessness). The pilots were the CNES cosmonauts Jean-Pierre Haignere and Jean-Marc Gasparini.

My thanks to the European Space Agency for this fantastic flight!

PIERRE-EMMANUEL PAULIS
Belgium



Lunokhod-3 in the Museum of the Lavochkin Scientific - Production Association near Moscow.

Military Space Programmes

Sir, In his fascinating article [1] on the Soviet early warning and RORSAT programmes, Dwayne Day makes the interesting assertion that: "Contrary to popular misconception . . . there were no early warning system satellites launched by the US between the launch of the last Program 266 [i.e. MIDAS] satellite on October 5, 1966 and late 1970 [i.e. 1970-93A, the first Defence Support Program (DSP) Block 1]". I am not clear what this "popular misconception" is, but the only candidate launches in this period are those referred to by the RAE tables as Ballistic Missile Early Warning Satellites (BMEWS) 1 and 2, 1968-63A and 1969-36A respectively, and the geostationary launches of 1970-46A and 1970-69A (still sometimes referred to as BMEWS 3 and 4).

Professor Des Ball, in his comprehensive monograph about the Rhyolite geostationary SIGINT programme and its successors [2], established that the first Rhyolite launch to be controlled from Pine Gap in Australia was one of 1970-46A or 1970-69A, rather than the 1973-13A launch which had first been

correctly identified through the espionage trial of Christopher Boyce and Daulton Lee [3]. 1968-63A and 1969-36A are usually identified with the 949 programme which was reported to be primarily a testbed for the later missile early warning spacecraft of DSP Block 1, but there is a belief [2,4] that they may have carried test instrumentation for the Rhyolite programme such as the prototype microwave antenna(e), or at the very least mapped the artificial and natural radio background spectrum at 6 Earth radii. This belief is largely based on the description of the 949 as an "integrated satellite" for which contracts were apparently placed in mid December 1966, and on a series of leaks to Aviation Week, and Missiles and Rockets cited in [2] and [4].

On a re-examination, prompted by Mr Day's assertion, the evidence for BMEWS 1 and 2 being early warning spacecraft is actually rather tenuous, and they have much more in common with the Atlas-Agena D launched Rhyolites than with the Titan IIIC launched DSP Block 1. No spacecraft picture of 949 has ever been

released, whereas the DSP series were unveiled in a limited way shortly after they became operational. This is, however, consistent with the need for limited publicity if an early warning system is to be credible, while even a partial SIGINT payload would (probably) require much heavier classification. More interestingly there have been no pictures of the late model Atlas Agena launchers, which by the early 1970s were only being used for BMEWS/Rhyolite launches from Cape Canaveral. The old Atlas Agena shroud was narrow at about 5 feet diameter compared with the 10 foot fairing of the Titan IIIC, and it is not clear in retrospect, why there would be two or three demonstration spacecraft constrained to this shroud, to fly only a year or two before the DSP Block 1 which was itself effectively a test series. However, the later reconditioned Atlas ICBMs that launched SEASAT, for example, have been seen with larger shrouds so this argument is not at all conclusive. The BMEWS 1 and 2 satellites were not apparently controlled from Australia [2,4], but in view of the degree of secrecy that

surrounded Rhyolite and the prevailing scepticism about its feasibility inside the CIA [2,3], the full scale investment in the Pine Gap facility might be expected to come later anyway. It is interesting however that Pine Gap was in use before the DSP ground stations at Nurrungar in Australia and Buckley in the US [2,4].

In a sense these arguments are all irrelevant, because we now know that the DSP series was deliberately used to mask geostationary SIGINT satellite operations [2,4] with very considerable success, as even in the late 1980s books were still being published (see for example [5]) that misidentified some of the Rhyolites and their successors as BMEWS or DSPs. It is thus actually quite possible that the "integration" of signals intelligence with early warning on the 949 satellites was disinformation to confuse industry observers. Eighteen months from contract award to (an exceptionally high-tech) prototype 949 spacecraft is, with hindsight, fast even for the mid 1960s, especially if the same contractors - TRW/Aerofjet - had also to deliver a different, larger, production DSP spacecraft for a different booster and shroud two years later. It is also worth noting that the DSPs were (and still are) spin-stabilised, whereas Rhyolite is commonly depicted (e.g. in [2,3]) as a body-stabilised vehicle, similar in appearance to the ATS-6 experimental comsat. Presumably a truly effective demonstration of geostationary SIGINT would also require a "staring", three-axis stabilised satellite, rather than a spinning, scanning one.

Another, even simpler, hypothesis is that the name "integrated satellite" is just a reference to the fact that DSP carries other payloads, notably the NUDETS nuclear explosion detection sensors, and even magnetospheric physics instrumentation [6]. It thus integrates the functions of MIDAS and Vela, no surprise for the large Titan III class satellite, but perhaps not so easy for the Atlas Agena. Perhaps, on balance, it is easier to believe that the Rhyolite series really began in 1968, while 949 was just the previous identification code to 647 which was used by the time DSP was first launched.

If Mr Day has new evidence to suggest that 1968-63A and 1969-36A were solely for the SIGINT purpose (and if, as he asserts, they were not BMEWS, it would be interesting to know what else they could be) then it is incumbent on him to produce it. The possible availability of a geostationary SIGINT satellite to the US up to two years before even the most careful observers [2,4] had realised is of considerable historical importance, as even a cursory look at the international situation of 1968-1970 (e.g. [7]) soon reveals.

N.W. WATKINS
University of Sussex, UK

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1. Dwayne A. Day, Soviet Military Space Programmes in the 1980s, *Spaceflight*, April 1995, p.117.
2. Des Ball, *Pine Gap*, Allen and Unwin, Australia, 1988.
3. Robert Lindsey, *The Falcon and the Snowman*, Pocket Books, 1980.
4. Des Ball, A Base for Debate: *The US*

Satellite Station at Nurrungar, Allen and Unwin, Australia, 1987.

5. Curtis Peebles, *Guardians: Strategic Reconnaissance Satellites*, Ian Allan, 1987.
6. Vincent Kiernan, 'Defense Satellites Carry Secret Science Instruments', *Space News*, 19-25 July 1993, p.25
7. Seymour Hersh, Kissinger, *The Price of Power: Henry Kissinger in the Nixon White House*, Faber and Faber, 1983.

The author, Dwayne Day, writes: Dr Watkins quite effectively summarises what I consider to be the "popular misconception" as established by Desmond Ball and others, concerning the development of the US early warning satellite programme. Dr Watkins logic is excellent. However, the story could not be cleared up until the acquisition of new evidence. Fortunately, beginning in the late eighties, much of that evidence surfaced. Some of it was classified whereas some of it was not classified, merely obscure.

One of the mistakes made has been to assume that simply because a programme number had been leaked, there were actually satellites flying under that programme number. That was not necessarily so. The Midas early warning test programme operated under the designation Program 461 (I made a mistake when I referred to Program 266 as Midas). In November 1965 a new designation, Program 266, was created to refer to a next generation geostationary orbit satellite. In November 1966 the number was changed to Program 949 and a month later TRW and Aerofjet General were awarded contracts to build the first satellites. In June 1969 the designation was changed again to Program 647 and the project was given a name: the Defense Support Program, or DSP. A little over a year later, in November 1970, the first satellite was launched into an improper orbit. This was the first early warning satellite launched since October 1966. This is quite clear for the declassified Space And Missile Systems Office histories. According to the official launch histories of the 45th Space Wing at Cape Canaveral, the three launches that Dr Watkins notes as having the RAE labels "BMEWS 1,2 and 4" were Program 827 launches. "BMEWS 3" was a Program 720 launch. None of these programme numbers had anything to do with early warning satellites. No satellites flew under the designations 266 or 949 and it appears as if most people associated with the programme never really referred to it as Program 647, preferring the easier "DSP".

The use of programme numbers for classified military space projects appears to have been rather haphazard. Some numbers were changed upon revelation in the open literature and also when the classified code-name of the project was revealed, as in the case of the convicted traitor Christopher Boyce who revealed secrets concerning a signals intelligence satellite. There are also indications that contractors sometimes had their own numbers which were different from the military ones. The degree of classification of these numbers is also questionable since some military officials still go into fits of apoplexy upon mention of "Program 777" despite various unclassified Air Force documents which state that this was the designation for the relatively open DSCS II communications satellites. As with all bureaucracies, the military space programme often suffers from left-hand/

right-hand coordination problems and far more information is available in unclassified sources than many government officials realise.

As for Dr Watkins' statement that the early warning programme was used to deliberately hide the classified signals intelligence programme (a charge made by Desmond Ball), this deception has not been proven. It appears more likely that in 1968, outside observers decided that they saw something other than what was really there and no one from the military bothered to change their misconception, since doing so would have required commenting on a highly classified satellite programme that was not early warning. DSP was never that highly classified and numerous pictures of the satellites were released before the programme was almost completely declassified in 1992. It would be fascinating to determine why some information was deliberately made public about DSP. My own personal belief is that the existence of an effective early warning system served a useful role as a deterrent to Soviet attack, particularly the highly destabilising Fractional Orbit Bombardment System (FOBS) developed by the Soviets in the late 60s.

A future three-part article that will hopefully soon be published will clarify the development of the Defense Support Program satellites. It will contain never-before-seen photographs of the satellites and information on their operational use. Reprinted below is a complete listing of all Midas launches, which were conducted in three series. Hopefully, this new information will help clarify the matter.

Midas Launches.

26 Feb 1960	Flight I
24 May 1960	Flight II
12 Jul 1961	Flight III
21 Oct 1961	Flight IV
9 Apr 1962	Flight V
17 Dec 1962	FTV 1205 Flight VI-failure
9 May 1963	FTV 1206 Flight VII
12 Jun 1963	FTV 1204? Flight VIII-failure
18 Jul 1963	FTV 1207 Flight IX
9 Jun 1966	FTV 1351 Flight X-failure
19 Aug 1966	FTV 1352 Flight XI
5 Oct 1966	FTV 1353 Flight XII

STS-63 Problems Explained

Sir, A clarification of the problems encountered with the two laser instruments on the STS-63 Mir rendezvous mission has kindly been provided to me by astronaut Jay Apt. He explained:

"The TCS (trajectory correction sensor) laser package on STS-63 worked much better than it had previously, but still had problems. When they got in close, the crew was asked to perform a procedure that the ground TCS folks thought would clear up a computer interface error; the crew did not have time. The ground had correctly interpreted the failure, and the procedures worked during the separation OK as I understand it.

"The hand-held laser system was difficult to use because it will give a different return if it is walked across different portions of Mir. We were cautioned against using it on Mir windows, which are the best flat surfaces."

NEVILLE KIDGER
Leeds, UK

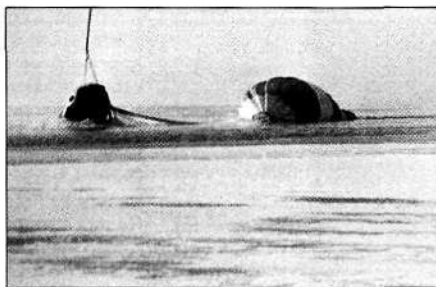
The Soviets' Only Water Recovery

Sir, I enclose three photos from the 1994 Chelomei Exhibition showing the water recovery of Soyuz 23, which came down in Lake Tengiz on 16 October 1976 during the night. According to Pavel Mukhortov, one of the Soviet journalists trained for a space flight in 1991/92, in his book *We All Are Aliens in This World* (Riga, 1992) the flight of Soyuz 23 was plagued by many problems. The bus carrying the cosmonauts Zudov and Rozhdestvenskiy to the launch pad on 14 October 1976 broke down. During ascent to orbit the launcher deviated from the flight path to almost the full extent allowed for and a launch abort was nearly executed. Soyuz 23 reached orbit, but due to this deviation this initial orbit was lower than planned. The automatic docking system "Iglu" failed during the approach to the Salyut 5 station and the rendezvous and docking was continued manually. But due to the lower initial orbit more propellant than usual was used up and the remaining fuel was enough for only one docking and for one de-orbit burn. The mission safety rules required, as mandatory, that enough propellant for two de-orbit burns should be reserved. The crew wanted to dock manually, but mission control cancelled the mission and ordered an immediate return.

The de-orbit and landing of Soyuz 23 was performed without problems on 16 October 1976, but the capsule came down in lake Tengiz during the night at an outside temperature of -22°C. The main parachute dragged the capsule over the water for some time. Some electrical connectors corroded in the salty water of lake Tengiz and the reserve parachute was deployed due to an electrical short. This reserve parachute became filled with water and sunk to the bottom of the shallow lake. Had the lake not been shallow the reserve parachute may have pulled the capsule below the water. Because the capsule was laying on its "side" as can be seen in the photos, the submerged exit hatch could not be opened and thus no fresh air could be admitted to the capsule.

The air inside the capsule volume was sufficient for two hours only, thereafter a special device provided breathable air for an additional five hours. All antennas of the capsule were also submerged in the water. While the cosmonauts could listen in to the communications of the rescue forces, they could not transmit a message themselves. Without a search signal a member of the rescue forces found the cosmonauts by chance but did not receive any sign of life from them. The inner wall of the capsule was covered by frozen ice and the cosmonauts stopped talking and moving in order to save oxygen.

Only after the bad weather had improved slightly in the morning could the rescue crew reach the capsule and attach a line to it. An Mi-6 helicopter could not even lift the capsule off the water but instead pulled it towards the coast of the lake. Finally after 11 hours the cosmonauts were able to leave the air-tight capsule. While the rescue personnel had already lost hope of finding the cosmonauts alive and were waiting for instructions on



The descent capsule of Soyuz 23 is dragged towards the coast of the partly frozen Lake Tengiz. The nearly collapsed parachute is still attached by lines.

(Photos: D. HAESELER)

Right: Cosmonaut V. Sudov during the first minutes after his exit from the Soyuz 23 descent capsule. He is protected from the cold by a leather cap and some blankets.

how to deal with the tragedy cosmonaut Rozhdestvenskiy opened the exit hatch himself. One picture shows cosmonaut Zudov a few minutes after finishing the arduous recovery operations.

This is the only water recovery to have taken place in the manned Soviet space programme. Cosmonauts are regularly trained for such an eventuality.

The Chelomei Exhibition was held in the Memorial Museum of cosmonautics, Moscow in 1994. I saw the exhibition twice, first one day before its official opening and again three months later. In the meantime some explanatory text plates had been changed and as a result my article about the Almaz space station in *Spaceflight* of October 1994, pp.342-344 incorrectly states that the manoeuvring engines of the TKS spacecraft with 400



The descent capsule floating in the waters of Lake Tengiz. The open parachute container is at the left while the (still closed) exit hatch is at the right at the waterline. Frogmen are seen in the small inflatable boat nearby.



kg thrust were developed by the Chemical Automatics Design Bureau (CADB), while in fact all engines for TKS, not only the small thrusters, were developed by the Chemical Machines Design Bureau. However, CADB developed the manoeuvring engine RD-0225 for the Almaz station itself as shown in the upper left photo on page 344. CADB officials confirmed that only engines for Almaz were developed by that design bureau, but none for TKS.

DIETRICH HAESELER
Taufkirchen, Germany

Cosmonauts Visit Hungary



Valentina Tereshkova with the writer.

Sir, From 1 to 4 June 1995, cosmonauts Valentina Tereshkova and Valeri Kubasov visited Hungary at the invitation of the Hungarian Army for the 15th anniversary of the Soviet-Hungarian space flight.

During their visit to Budapest they met Hungarian journalists and gave interviews recalling the memory of their space flights and answering questions.

Bertalan Farkas was the first Hungarian cosmonaut and Béla Magyari was his back-up. Tereshkova presented them with gifts.

On 23 May the two Hungarian cosmonauts were promoted. Bertalan Farkas is a brigadier-general and Dr Béla Magyari is a colonel.

NANDOR SCHUMINSZKY
Hungary, BIS Member

Caption Correction

Sir, I refer to the Mir Mission Report in *Spaceflight*, June 1995, p.190. The caption on this page says:

"Inside the Mission Control Centre at Kaliningrad during the tracking of an earlier Soyuz spacecraft".

The picture shows the Mission Control Centre during operations of one of the two Vega Venus Halley probes in 1986. Clearly visible in the upper right corner of the photograph is a diagram of Vega.

REGINALDO MIRANDA JUNIOR
Brazil

Ed: The confusion arose as the original picture was juxtaposed with one of a Soyuz spacecraft. Our apologies for the error.

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Classification of Soviet/Russian Launch Vehicles

Sir, In the Soviet Union there was no tradition of giving names to boosters. The well known names (Soyuz, Vostok, Molniya, Proton) were inaugurated later for the benefit of the West.

Every missile or launch vehicle usually acquired the letter R (Raketa, i.e. missile), UR (Universalnaya Raketa, universal booster) or N (Nositel, i.e. launch vehicle) and a number.

There is an alphanumerical code in use for technical documentation which can be explained as follows:

1. First number and letter:

8K - missile 11A - launch vehicle
11K - modified missile for launching satellites

2. Second number (after letter): design bureau

5 - ?? 6 - Yangel 7 - Korolev
8 - Chelomei 9 - Koslov?

3. Third number: sequence of development

4. Second letter (U, M, L); modified booster

Compared to the western classification systems (Sheldon, DoD) it should be noted that there exist a lot of modifications on every Russian booster. The Western systems do not record the different modifications and have used the same designation for different boosters.

The survey published here is of Soviet/Russian launch vehicles used since 1957 and in the near future and is not complete. The tables include some other projects too and I would like to hear from other space enthusiasts in order to improve them.

STEFAN WOTZLAW
Dessau, Germany

Korolev Design Bureau/OKB-1/NPO Energiya/KB Koslov/CSDB.

Name	Desig.	Article	DoD	Sheldon
Energiya			SL-17	K-1
Molniya ⁽¹⁾	R-7A	8K74	SL-6	A-2-e
Molniya ⁽²⁾		8K78	SL-6	A-2-e
Molniya-M ⁽³⁾		8K78M	SL-6	A-2-e
	N-1	11A52	SL-15	G-1
RUS				
Soyuz		11A511	SL-4	A-2
Soyuz-L ⁽⁴⁾		11A511L	SL-4	A-2
Soyuz-U ⁽⁵⁾		11A511U	SL-4	A-2
Soyuz-U2 ⁽⁶⁾		11A511U2	SL-4	A-2
Sputnik	R-7		SL-1	A
Sputnik	R-7		SL-2	A
Vostok			SL-3	A-1
Vostok-L			SL-3	A-1-e
Vostok-M ⁽⁷⁾		8A92M	SL-3	A-1
? ⁽⁸⁾	R-7		SL-5	A-m
Vostok ⁽⁹⁾	R-7		SL-10	A-1-m

- (1) First version of the four-stage variant of the famous R7 Semyorka ICBM. Used for the first interplanetary launches in 1960/61.
- (2) Improved version for interplanetary and highly elliptical Earth orbital missions (Molniya orbit).
- (3) Current version of Molniya launcher, in operation since 1969.
- (4) Special version with onion-shaped payload shroud for testing Lunar Lander (LK) in Earth orbit (payload T2K).
- (5) Recent version for unmanned payloads (Progress-M, Yantar, Resurs F, Foton).
- (6) Recent version for manned missions with Soyuz TM spacecraft.
- (7) Recent version used for Sun synchronous missions (Indian IRS, Russian Resurs-O1).
- (8) Version of Vostok launcher minus upper stage used for Polyot ASAT missions in 1963 and 1964. Russian designation or name unknown.
- (9) Launch vehicle of Cosmos 102 and 125 in 1965 and 1966. Believed to be a Vostok launcher with manoeuvring upper stage. Not confirmed by Russian sources yet.

Yangel Design Bureau/OKB-586/NPO Yuzhnoye.

Name	Desig.	Article	DoD	Sheldon
Cosmos 21 ⁽¹⁰⁾	63S1	11K63	SL-7	B-1
Cosmos 2M ⁽¹¹⁾	63SM	11K63M	SL-7	B-1
Cosmos 3I ⁽¹²⁾	65S3	11K65	SL-8	C-1
Cosmos 3M ⁽¹³⁾		11K65M	SL-8	C-1
Tsiklon-1	R-16	11K64		
Tsiklon-2	R-36M	11K69	SL-11	F-1
Tsiklon-3	R-36	11K68	SL-14	F-2
	R-56 ⁽¹⁴⁾			
Zenit 2		11K77	SL-16	J-1

- (10) First launcher version of R12 IRBM (8K63), first launch (failure) in 1961.
- (11) Second version of R12 IRBM satellite launcher modification.
- (12) First launcher version of R14 IRBM (8K65) produced by Branch No.2 of OKB-1 in Krasnoyarsk-28, Siberia.
- (13) Current version of R14 IRBM for launching satellites into intermediate and low Earth orbits, promoted by Polyot enterprise of Omsk, Siberia.
- (14) Project for a Moon rocket in competition with N-1 and UR-700.

Chelomei Design Bureau/OKB-52/NPO Mashinostroeniye/KB Salyut/Khrumichev State Enterprise.

Name	Desig.	Article	DoD	Sheldon
Proton 2	UR-500	8K82	SL-9	D
Proton 4 ⁽¹⁵⁾	UR-500K	8K82K	SL-12	D-1-e
Proton 3	UR-500K	8K82K	SL-13	D-1
Proton KM		8K82KM		
Vulkan ⁽¹⁶⁾	UR-700	8K83		
Rokot				

- (15) Four-stage version of Proton with Block-DM upper stage.
- (16) Project for a Moon rocket in competition with R56 and N-1.

Early Space Policy: Link with MOUSE

Sir, With regard to Dwayne Day's comments on the derivation of Project Orbiter [1] and the influence of James Van Allen and Fred Singer, he should be aware that the BIS papers (1948-51) sought proof of the ability to *launch* small payloads into close Earth orbit. They were not concerned with defining the satellite itself except in very general terms. The connection with the MOUSE project is acknowledged by an exhibit in the National Air and Space Museum, Washington DC, constructed by Dr Singer in 1954 (which, incidentally, includes some of the earliest solar cells provided by Bell Telephone Laboratories). A descriptive panel reads:

"The MOUSE (Minimum Orbital

Unmanned Satellite of the Earth) was conceived in 1951 as the smallest possible orbital vehicle capable of performing important scientific tasks.

"When complete, MOUSE would have weighed 45.4 kilograms (100 pounds) and would have included instruments to measure cosmic rays, interplanetary dust, and solar ultra-violet and X-rays. The satellite, powered by solar cells, was to be spun on its long axis, with its instruments carried on the rods projecting from either end.

"MOUSE was conceived by Kenneth W. Gatland, Anthony Kunesch, and Alan Dixon, and was designed by Dr S.F. Singer of the University of Maryland. Although the proposal aroused interest, government support was not forthcoming and the satellite was never built."

Publication of our "minimum" launcher studies between 1948-51 - like the 1945 classic paper by Arthur C. Clarke on 24-hr orbit communications satellites - was deliberately encouraged by the BIS to advance the cause of astronautics internationally at a time of great scepticism for the subject, even among leading scientists. A more detailed explanation of the link with Project Orbiter of 1952-54 (Office of Naval Research, Washington) and Fred Singer's MOUSE project, will be found in the paper, "Prelude to the Space Age" [2].

KENNETH W. GATLAND
Epsom, Ewell, UK

References

1. *Spaceflight*, 37, 5, May 1995, p.170.
2. *Spaceflight*, 24, 11, November 1982, pp.386-392.

Cosmos 1374 Photographs

Sir, In September 1991 *Spaceflight* published a letter by me informing readers that photographs from two different space plane retrievals by the Russians (Cosmos 1374 and 1445) had been released, and this was made evident by my analysis of two of the photographs [1].

Subsequently, in the correspondence section of the magazine in February 1992, James Oberg claimed that my "elaborate conclusions" were "invalid", and that actually the two photographs published by *Spaceflight* were of one space plane retrieval - that is, the Cosmos 1445 recovery [2]. I can only hazard the guess that Mr Oberg's conclusion was based on the fact that only Cosmos 1445 pictures had appeared in the World aerospace press up to that time.

Since that time, I have been able to acquire first-generation prints made from the original negatives of Cosmos 1374 retrieval direct from the Royal Australian Air Force, and these confirm my original analysis. Two of these photographs (untrimmed) appear on the right.

PETER PESAVENTO
California, USA

References

1. P. Pesavento, Cosmos 1374, 1445 Photographs Compared, *Spaceflight*, 33, p.311, 1991.
2. J. Oberg, Spacecraft Design Histories, *Spaceflight* 34, p.67, 1992.

Cosmos 1374 recovery showing the space plane being moved on the deck of its recovery ship on 4 June 1982.



Another photograph taken on 6 June 1982 of the recovery of Cosmos 1374.

Both Photos:
WING CMDR N. COOPER,
ROYAL AUSTRALIAN AIR FORCE
(RAAF BASE WILLIAMS,
AUSTRALIA)

Early Space Policy

Sir, I refer to the correspondence between Ken Gatland and Dwayne Day regarding the early space policy of the United States and the orbiting of the first US satellite. (May 1995 issue of *Spaceflight*). If I may be permitted to throw a pebble into the muddied waters perhaps the following information may be of use in any further discussions.

The earliest mention of satellite applications in the US might well be a study begun in March 1946 as part of the RAND Project established by the Army Air Forces. They filed a report on the 12th of that month entitled, "Preliminary Design for an Experimental World Circling Space Ship". This was matched in the same month by the Chief of Naval Operations who directed the Navy Bureau of Aeronautics to conduct a similar survey. The interest so expressed by both parties clearly shows that inter-service rivalry was evident long before there was a choice to be made between Orbiter and Vanguard.

Leaving aside the setting up and development of Project Vanguard, the programme that grew into Orbiter seems to have come from a meeting held on 25 June 1954 when von Braun, Frederick Durant, Alexander Satin, Fred Whipple, David Young, Dr S.F. Singer and George Hoover reached the conclusion that a Redstone missile fitted with a Loki cluster as a second stage had the capability to launch a satellite into a 200 mile high orbit of the Earth.

[House Report 67, 87th Congress, 1st session, p.19]

A year later, in September 1955, in response to the decision by the US to launch a satellite in the forthcoming IGY,

the Stewart Committee of the Department of Defense reviewed the alternatives for launching an Earth satellite. There were to:

1. Wait for the Atlas launcher;
2. Use a modified Redstone (Project Orbiter);
3. Develop a launcher from the Viking missile (Project Vanguard).

The vote was 7 - 2 for abandoning the Redstone concept and Secretary Donald Quarles ruled with this majority verdict.

[House Report 67, 87th Congress, 1st session, p.23]

In February 1956 the Army Ballistic Missile Agency was activated to develop the Redstone and its deriving partner, the Jupiter. By August 1957 this had reached the point where they were able to fire a Jupiter C to an altitude of 600 miles on a flight which successfully re-entered a nose cone over a thousand miles down-range from the launch site. The general opinion was that had permission been given, this flight could have orbited a satellite.

There matters rested until Sputnik 1 in October 1957. A month later, on 8 November, Secretary of Defense Neil McElroy directed the Army to proceed with the launching of the Explorer satellite, probably a wise move in the light of the Navy failure in December.

[Origins of MSFC, p.45 - Akens]

Does this shed any light on the question raised by Dwayne Day?

E.T. PUGH
Essex, UK

Dwayne Day writes: Mr Pugh adds further important details to the story of the selec-

tion of the Jupiter versus the Vanguard. He makes an important point by stating that inter-service rivalry was a factor in the debate. Unfortunately, the question I raised in my original article in the November *Spaceflight* remains unanswered. Why, after the Vanguard choice had clearly been made, was the issue reopened again in mid-1956? And who reopened the issue? Unfortunately, these questions probably cannot be answered until new information is uncovered. I have spent considerable time on these questions to no avail.

Historians studying this issue have generally identified several reasons why the United States was not the first to launch a satellite into orbit. These are: The unimportance placed upon such a feat by many within the administration, particularly the president himself, despite several warnings in secret policy documents; the desire by Eisenhower that the US space programme not appear overly militaristic by using military IRBMs like the Jupiter; the desire to precede any US military space launch with a more civilian one; the desire to participate in such an activity only as part of the International Geophysical Year and not as part of some propaganda stunt; and the possible desire to allow the Russians to establish "right of overflight" with a satellite before the US. To these I would add the desire by many to keep von Braun and his team focused on the missile problem instead of getting too carried away with the exploration of space. All of these issues must be looked at collectively, since it does not appear as if any single one was dominant.

But the currently hot issue in historical circles concerns the overflight and "stalking horse" questions. It must be remembered that at the time the United States was engaging in a series of provocative and illegal

Arts & Letter Space AGE CD-ROM Multi- media Encyclopedia (October 1994 update)

Computer Support Corporation, 15926 Midway Road, Dallas, Texas 75244 USA; Tel 214-661-8960; Fax 214-661-5429. Requires: PC Compatible 386 or better, Mouse, MS Windows 3.1 or higher, 256 colour VGA display, Sound Card. 8.7 Mbytes Hard Disc Space recommended for best speed but will also run direct from CDROM. US Price \$29.95.

Space AGE runs under Windows and comprises an eponymous multimedia encyclopedia on Space and a graphics package; Arts & Letters DRAW which is supplemented by Space Clip Art. The publishers intend to update the encyclopedia regularly to keep the coverage up to date. The idea behind Space AGE is that users will consult the encyclopedia section and may then use the graphics package to apply what they have learned to generate art work. Articles can be annotated with User supplied text without leaving Space AGE and the annotated text can be copied to the Windows Clipboard. Text entries (but not images) can be printed out.

The encyclopedia is well equipped with numerous images, audio narratives and text information organised into eight subjects: Robotic Missions, Human Missions, Space Stations, Launch Vehicles, History and People, Space Centres and the Future. There is also a "Space Theatre" with a choice of sixteen audio-video clips and four narrated slide shows. No animations are included. The encyclopedia coverage is very up to date, including for example text and images on the collision of Comet Shoemaker-Levy with Jupiter, the flight of the DCX SSTO prototype and results from Clementine. There is also interesting audio-

Space Computer Software

visual material on events of the 1950s and 1940s, as well as the more usual coverage of the Solar System, Moon Landings, Space Probes and the US and Russian Space Programmes. The encyclopedia is rounded off with a hot-linked index and a comprehensive appendix supplying definitions, bibliographies of references, publications, bulletin boards, space societies and organisations (but not so far the BIS!), biographies of astronauts and other contributors to astronautics. The coverage is international but favours US persons and organisations.

Arts & Letters DRAW which accompanies the encyclopedia, is a Vector-based Colour Graphics Package which supports freehand drawing tools, libraries of Colour Clip Art and a variety of facilities for rotation and scaling, shading and palette changes, and typefaces/text manipulation. Drawings can be printed out or exported for use in other documents via the Windows Clipboard. There is Space Clip Art for general purpose use (scenery and banners for example), as well as detailed drawings of Space Probes, launchers and the Freedom Space Station, besides a selection of other drawings of more general interest. There is a 37 page user manual which is entirely devoted to describing the available facilities.

Overall, Space AGE was easy to install and operate on the review machine (33 MHz 486 DX with 8 Mbytes of RAM), on which the sound and still picture quality appeared very good. The program responded promptly to keyboard/mouse commands. Video images and playback rates were less satisfactory, however,

but still adequate. The combination of encyclopedia and drawing programme in one package is unusual but works well and it was easy to create complicated but pleasing illustrations with accompanying text. Both manuals included were well produced and easy to use and both packages include on-line help.

Space AGE should find application both within the home and schools as a reference and educational work and also wherever there is a need (as in clubs and societies) to put out illustrated material.

Britain's Place In Space; The Multimedia Index

HMSO Electronic Publishing, St Crispins, Duke Street, Norwich NR3 1PD. Available on CD-ROM from HMSO Publications Centre, PO Box 276, London, SW8 5DT; Tel 071-873-9090. Price £70.50. Minimum System Requirements: 386 PC, 4 Mbytes RAM, CDROM Drive, Windows 3.1 and SVGA Monitor displaying 640 x 480 resolution and 256 colours. Recommended System: as above but 486 PC, 8 Mbytes RAM, Sound Card, 16 bit colours.

"Britain's Place In Space: The Multimedia Index" was put together at the British National Space Centre (BNSC) primarily to assist schools in teaching space-related aspects of the UK National Curriculum. The product works in three ways: firstly, there is a text database of British organisations in Government, Commerce and Education with their space related activities, interests and contact points. The user can specify a search phrase and print out entries in which it occurs. Next is a set of eleven nar-

rated (text or voice) short slide shows covering basic space concepts and the British role in space organisations and projects. Lastly, there is a range of space images and videos, relevant parts of the National Curriculum, ideas for school projects and basic advice to teachers which is accessed from outside the main programme. This is supplemented by a range of space images in the BMP, DIB, GIF and PHOTOCD file formats; for which the user must supply a separate viewer. Unusually, the publishers have stated that all the material on the CDROM may be copied - for use in educational projects only.

"Britain's Place in Space" was easy to use, but ran slowly on the review machine (a 33 MHz 486 PC) and images at the minimum colour resolution were indistinct.

The presentation sound quality was good but the scripts sometimes sounded patronising and superficial to this reviewer, perhaps because they were aimed at pupils more than teachers. The presentations could raise user expectations too high because the frequent references to exciting topics like the first UK Astronaut, ESA Launchers, Cassini, Huyghens, Rosetta, the Space Shuttle are misleading without acknowledgement that, given current priorities and budgetary constraints in Government funding, British participation in such projects has been (and is likely to be) relatively minor with job opportunities therefore strictly limited.

.....

*These reviews are compiled by
G.C. Carter.*

*Full publication details are given
to enable copies to be ordered
from each publisher, for many
items can now be ordered direct.*

*If not, they will supply the
address of a local agent who can
handle matters.*

CORRESPONDENCE (continued)

U-2 spyplane overflights of the Soviet Union. It was still an open question at that time as to where a country's "airspace" ended and "space" began. Since the U-2 was considered to have a limited useful life (it was originally thought that the Soviets would be able to shoot it down in 1958, but this did not happen until 1960), it was expected that satellites would eventually have to take over this mission. Establishing the right of overflight, so that the first US satellite to overfly Soviet territory did not start a war, was considered important in this context. Several historians have endorsed the idea that the US Scientific Satellite Program was intended to serve as a "stalking horse" for future reconnaissance satellites. Donald Quarles, who held several positions during this period, is thought by many to be the key to this theory, since his imprint is on all the major space policy decisions at the time.

Unfortunately, Quarles died in 1959, and did not leave much in the way of records.

His papers, many of which are still classified, do not answer the question of whether he endorsed the right of overflight idea according to those who have seen them. But there are indications that Richard Bissel, who headed the U-2 programme for the CIA and who also headed the reconnaissance satellite programme, was actively involved in planning for the Scientific Satellite Program. To my knowledge, no one has looked at his records regarding this issue and they remain classified. Even then, early reconnaissance satellite issues were rarely committed to paper and were treated much like Britain's Ultra secret - with only a few key players knowing the details. It is not clear if Bissel's papers would hold an answer.

There are other avenues to be pursued as well. Major General Glen Medaris, then head of the Army Ballistic Missile Agency, testified in front of Congress and wrote in his memoirs that he was specifically ordered from Washington (he did not indicate by whom) to check all Jupiter launches to make sure that von Braun and his people did not "accidentally" launch a satellite into

orbit by fuelling the upper stage. Such orders might have indicated what the concerns with such a launch were. Despite extensive searches, I have not been able to locate any written orders from anyone in Washington to Medaris concerning this issue. Medaris himself remains a dubious source, since he is widely regarded as eccentric and egotistical. I believe he was telling the truth, but these vital documents, if they exist, have proven elusive.

The other avenue I have pursued is to seek declassification of the records in the Eisenhower Library concerning early space flight. I have requested the mandatory declassification review of the "Rockets and Missiles" folders which contained the documents referred to in my original article. So far, this has produced only documents relating to modifications to the Redstone in military service and priorities for other ICBM programmes, nothing on their relationship to the Scientific Satellite Program. Hopefully, there may be something more interesting still hiding under the cloak of a four decade classification order.

'Rocket Engine' Competition

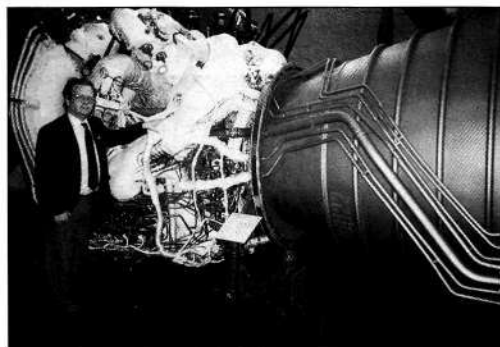
The capability of space launcher vehicles to lift large payloads into orbit stems directly from the development of large rocket engines with high thrust. Whereas photos of large launch vehicles, either on the launch pad or in flight, may be familiar, those of their rocket engines are less often seen. Four such examples are shown below and the photos also offer clues to their identification with an opportunity to win a prize from the collection of new BIS Space Shuttle videos*.

Prizes: The first five correct entries to be opened after the closing date of 7 September 1995 will receive a copy of the following video which is one of the recent additions to the BIS Space Shuttle Video Collection*:

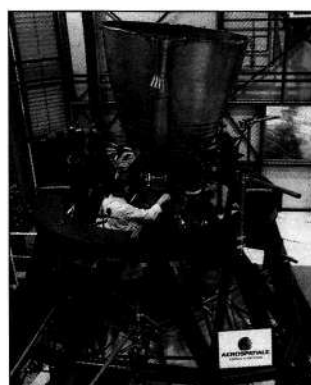
STS-65 Mission Highlights

For details of this video and those of other Space Shuttle missions, please see the inside front cover.

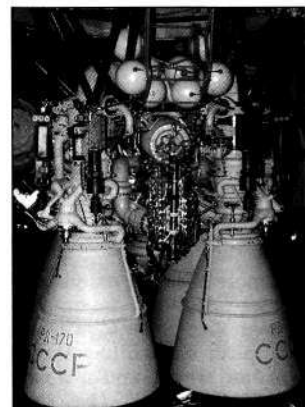
To Enter: Enter the name of the launch vehicle for which each of these four rocket engines was developed. The names appear in the following list: Ariane-5; Energiya; Proton; Saturn V; Shuttle Orbiter; Zenit:



A



B



C

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England
To arrive by first delivery on 7 September
1995.

Entries may be submitted on a photocopy
or otherwise written out in a clear and
unambiguous form.

*Tapes are VHS PAL format only and are
not compatible with the US NTSC system.

Photos: Th.P./SIC, Peter Gualtieri (West Kentucky
News), and Aerospatiale.



D

Title/Name

Address

Spaceflight Crossword

No. 24

ACROSS

1. Perform surgery
5. Space launcher to reach satellite of Saturn ?
8. Ferments
9. First American in space
10. Place to see IMAX film
11. Speak slowly
12. Roundabout route
14. Cosmonaut with first space flight in 1977
17. Very young person
19. Contrary to law
22. Sickness
23. Particles of photographic emulsion
24. Rocket attitude detectors
25. Type of energy source

DOWN

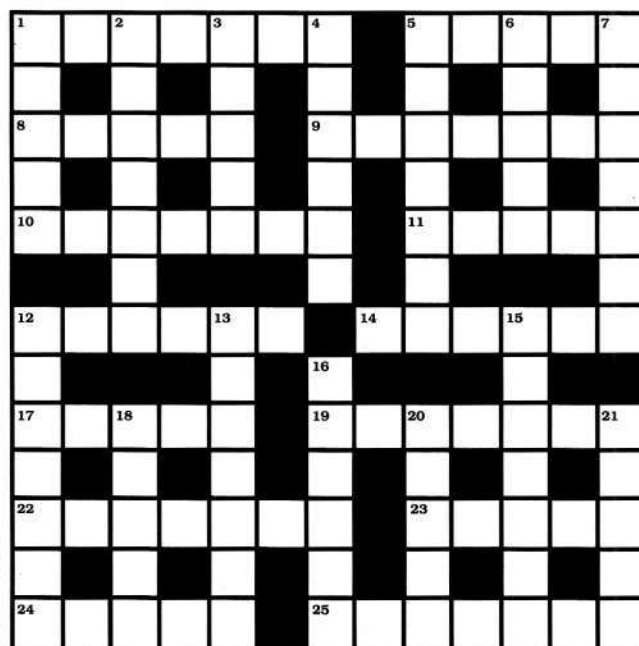
1. Path of a spacecraft
2. Electrode
3. Organisation of radio amateurs and others interested in space communications
4. Teaser (ana.)
5. Day of the week
6. Ornamental head-dress
7. Name associated with Baikonur accident of 1960
12. Joining up of spacecraft
13. Strip
15. Captain of industry
16. Commander of Atlantis Mir docking mission.
18. Clock-watcher
20. Computer circuitry
21. Pertaining to the Moon

Solution will appear in the September issue.

Solution to Crossword No.23.

ACROSS: 1. Anik; 3. Spacelab; 9. Glenn; 10. Lampton; 11. Eye; 13. Populates; 14. Vacuum; 16. Exodus; 18. Solstices; 20. STS; 22. Budarin; 23. Hydra; 25. Essayist; 26. Ages.

DOWN: 1. Angle; 2. IUE; 4. Palapa; 5. Complex; 6. Latitudes; 7. Bonuses; 8. Snap; 12. Enceladus; 14. Visible; 15. Utterly; 17. Scones; 19. Soho; 21. Stars; 24. Dig.



SATELLITE DIGEST-279

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

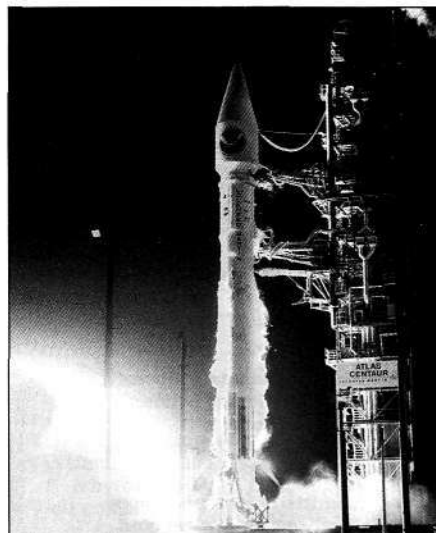
Spacecraft	Int'l Desig.	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
USA 110	1995-022A	May 14.57	ER	Titan-4/Centaur	4,500 ?	No orbital data issued - geosynchronous orbit ?					[1]
INTELSAT 706	1995-023A	May 17.27	Kourou	Ariane 44LP	4,180	Jun 1.22	0.06	1,435.90	35,729	35,837	[2]
Spektr	1995-024A	May 20.15	Tyuratam	Proton-3	19,640	Jun 1.85	51.65	92.49	393	400	[3]
GOES 9	1995-025A	May 23.24	ER	Atlas 1	2,105	Jun 2.70	0.29	1,434.74	35,633	35,887	[4]
Cosmos 2312	1995-026A	May 24.84	Plesetsk	Molniya-M	1,900 ?	May 27.35	62.89	717.66	604	39,745	[5]
UFO 5	1995-027A	May 31.64	ER	Atlas 2	3,000 ?	May 31.73	26.97	461.58	290	26,522	[6]

NOTES

1. No details released of this classified Department of Defense launch. Payload is reportedly an ELINT satellite in geosynchronous orbit.
2. Communications satellite, built by Space Systems/Loral for INTELSAT. Mass of the satellite quoted above is at launch: the dry mass of the satellite is 1,776 kg. Initially located over 304 °E: to be operated over 307 °E.
3. Remote sensing module (also designated Module O, 77KSO before launch), launched to dock with and expand the capabilities of the Mir Complex. Some sources quoted the mass of Spektr as 23.5 tonnes, but this figure appears to include the payload shroud and/or a payload interface unit. Dry mass of the basic module is 11.5 tonnes. Aboard the spacecraft are additional equipment for the Mir Complex (3.24 tonnes), "structures for payload deployment" (not otherwise identified, 3.85 tonnes), scientific equipment (2.15 tonnes), United States equipment (700 kg), general cargo, consumables (1.26 tonnes). Spacecraft docked with Mir Complex 1995 June 1.04 at the +X axis (front longitudinal port), relocated to -Y axis during approximately June 1.7-1.8 where it will be permanently positioned.
4. Satellite called GOES J ("Geostationary Operational Environmental Satellite") prior to launch: part of U.S. National Oceanic and Atmospheric Administration's (NOAA) programme to provide synoptic visible and infra-red imaging and an infra-red/thermal sounding for atmospheric temperature profiles. To be operated over 225 °E.
5. "Okol" early warning satellite: orbital plane suggests a replacement for Cosmos 2063.
6. "UHF Follow-On" satellite, also called USA 111. Mass of the satellite on-station is 1,360 kg.

ADDITIONS AND UPDATES

- 1983-026B TDRS 1 was manoeuvred off-station over 83-84 °E approximately 1995 May 9. The satellite is still drifting to the east at the end of the month.
- 1983-047A INTELSAT 506 was manoeuvred off-station over 309-310 °E approximately 1995 May 8-9 and was relocated over 328-329 °E approximately May 24.
- 1983-094A RCA Satcom 2R was retired from service 1995 February 28.
- 1986-017A The arrangement of modules on the Mir Complex changed during May-June 1995 in readiness for the arrival of Spektr (1995024A, see above) and operations with the United States shuttle orbiter Atlantis on the STS-71 mission. During May 26 the Kristall module (1990-048A) was relocated from the -Y radial axis to the +X (front) longitudinal axis. On May 29 a further relocation rotated Kristall from the +X to the -Z radial axis where it remained during the docking and relocation of Spektr. When Spektr docked (see entry above) June 1 it was initially at the +X port and was then transferred to the -Y radial axis. A further Kristall rotation is planned for June 7 when it will be rotated from -Z to +X in readiness for the arrival of Atlantis later in the month. (All axes refer to the Mir Core.)



Atlas 1 (Atlas/Centaur 77) is launched from Pad 36B Cape Canaveral Air Station at 1.52 am EDT on 23 May to put the advanced US weather satellite GOES J into geostationary orbit. At the base of the rocket are seen the diagonal jets from the Vernier engines which steer the vehicle. After a one-day delay due to a faulty battery, a launch attempt on 20 May had to be scrubbed, before the close of the 1 hr 13 min window, due to high winds and lightning. Engineers inspected the separation bolts for integrity before making a new attempt, which was delayed until 23 May due to workers on the adjacent Pad 36A mating the US Navy's UHF satellite to Atlas 2 which was subsequently launched on 31 May.

PETER GUALTIERI, WEST KENTUCKY NEWS

- 1986-017JE GFZ 1 was ejected from Mir 1995 April 19.80.
- 1989-004A Gorizont 17 stabilised its longitude over 33 °E approximately 1995 May 11-12.
- 1989-020B METEOSAT 4 was manoeuvred off-station over 352 °E approximately 1995 May 10. At the end of the month the satellite was still drifting to the east.
- 1995-014A Cosmos 2311 was de-orbited 1995 May 31: if it came down on a normal recovery pass then it would have re-entered the atmosphere approximately May 31.8.
- 1995-017 Both ORBCOMM 1 (1995-017A) and ORBCOMM 2 (1995-017B) have started operating following communications problems immediately after launch.
- 1995-018A A small orbital manoeuvre appears to have been completed by Ofeq 3:- May 22.50, 143.38°, 95.54 min, 367 km, 722 km (pre-manoeuve orbit) May 23.23, 143.37°, 95.59 min, 369 km, 725 km
- 1995-019A Add the following orbit for AMSC 1:- May 21.54, 0.02°, 1,436.05 min, 35,777 km, 35,794 km The satellite's location has been stabilised over 258-259 °E.
- 1995-020A Progress-M 27 undocked from the Mir Complex 1995 May 22.99 and was de-orbited May 23.14: debris was expected impact the Pacific Ocean approximately 3,600 km south-east of New Zealand. No mention was made of an attempt to recover a Raduga capsule.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

6 September 1995

7 - 8.30 pm

STRV Satellites: Mission and Results

Dr Andrew Sims

DRA Farnborough

On 17th June 1994, two small satellites built by the Defence Research Agency were launched from Kourou, French Guyana as auxiliary payloads on Ariane flight V64. Placed into Geostationary Transfer Orbit, the mission of the two 52kg "Space Technology Research Vehicles" is to demonstrate the in-orbit performance of novel technologies and to make supporting measurements of the space environment. The talk will focus upon lessons learned from the new technologies - both during development and in-orbit and on results from a variety of radiation monitors flown on both satellites.

16 October 1995

7 - 8.30 pm

ESA's ARTEMIS Mission: An Operational Test of Ion Propulsion

Dr D.G. Fearn

DRA Farnborough

Ion propulsion, the "ion drive" so often mentioned by science fiction authors, is soon to have an opportunity to demonstrate its capabilities on ESA's ARTEMIS experimental communications satellite. Ion thruster systems from the UK and Germany will be used for operational north-south station-keeping for the 10 years life of this satellite. The lecture will explain the principles behind this technology and will then describe its application to communications satellites, concentrating on ARTEMIS and pointing out the resulting operational and financial benefits.

1 November 1995

7 - 8.30 pm

Mini Black Holes

Bernard Carr

Queen Mary & Westfield College

Small black holes may have formed in the early Universe when the density was very high. Such primordial black holes are of particular interest because they are the only ones small enough for quantum effects to be important, those smaller than 10^{-16} g having evaporated by now as a result of the Hawking process. We discuss their possible observational consequences.

22 November 1995

7 - 8.30 pm

SAREX

Mr Will Marchant

The Shuttle Amateur Radio Experiment (SAREX) is an amateur radio station flown on about half of the NASA Space Shuttle Missions. It is primarily used for contacts between the astronauts and school students during the mission. The speaker will present a SAREX related slide set that he has created for use by NASA Educational Personnel.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

AN EVENING TO HONOUR ARTHUR C. CLARKE

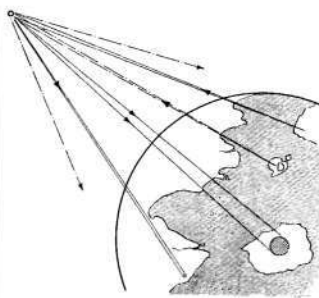
Theme Title

"VOICES FROM THE SKY"

at 6.00 pm on 18 August 1995

at

The Scientific Societies Lecture Theatre,
Fortress House,
New Burlington Place, London W1



The BIS proudly presents a programme involving satellite links between Dr Arthur C. Clarke in Sri Lanka, the

Honourable Dan Goldin, NASA Administrator, a Senior Representative from INTELSAT, in the USA, and those present at the Society's gathering in London to honour the 50th Anniversary of the concept of geostationary satellites advanced by Arthur in 1945.

Honours to Arthur will include the Society's Space Achievement Medal, a special commemorative plaque and a presentation from ERA Technology.

The evening will also feature Addresses of Welcome by a number of guest speakers and conclude with a special Buffet Reception.

A small number of tickets are still available to members at £20 per person but please apply immediately to the *Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.*

This event is being sponsored by BT Communications, Intelsat and ERA Technology.

7 December 1995

7 - 8.30 pm

Space, The Medical Challenge

Dr Mike Harrison

Defence Research Agency Centre for Human Sciences, Farnborough

Radiation, vacuum and absence of gravity combine to make space an environment that is overwhelmingly hostile to life. Add confinement and isolation in a fragile habitat, a vulnerable life support system, and the remoteness of help and rescue, and you have the ultimate human challenge - the permanent occupation of space. The talk addresses some of the key medical issues involved in responding to that challenge.

12 August 1995

50th Annual General Meeting

The 50th Annual General Meeting of the Society will be held at The Scientific Societies Lecture Theatre, Fortress House, New Burlington Place, London W1, on Saturday, 12 August 1995 at 12 noon.

Admission is by ticket, available to Corporate Members (i.e. Fellows of the Society) only, who should apply in good time enclosing a stamped addressed envelope.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

13 September 1995

10 - 4.30 pm

Low-Cost Satellites

Many organisations have been trying to reduce costs substantially, mainly by the innovative design of micro- and minisatellites. Some of the topics relevant to this theme will be presented.
Organiser: Dr D.G. Fearn

27 March 1996

10 - 4.30 pm

Call for Papers

Space Transportation

For over a decade the BIS has run symposia on the subject of space transportation. These are intended to provide a forum to cover all aspects of the space infrastructure including the rationale for infrastructure development, system concepts and technology issues. In the past these symposia have been key to the development of HOTOL, Skylon, the Polar Platform and UK thinking on space industrialisation as a part of mankind's future.

Organiser: Mark Hempell

14 - 20 July 1996

Cospar '96 Commission F Assembly

The next biennial assembly of COSPAR, the international Committee for Space Research, will take place in Birmingham. These biennial Commission F conferences (the last was held in Hamburg in 1994), provide one of the most important forums for the discussion of the present status and future directions of space research.

In recognition of the part BIS has played over the past decade in publishing scientific research papers on the relatively new and now rapidly evolving subject of planetary environmental engineering - terraforming - the Society has accepted the invitation of COSPAR to co-sponsor the F3.4 symposium. The organiser of the programme of the symposium *Implanting Life on Mars* is Prof. Robert H. Haynes (President of the Royal Society of Canada) and it is scheduled to be the three hour evening session of the opening day of the conference July 15, 1996.

Fuller details will be published at a later date.

IAF CONGRESS

Benefits of Space for Humanity

The 46th IAF Congress of the International Astronautical Federation will be held in Oslo, Norway, 2-6 October 1995.

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Buzz Aldrin
Member of the British Interplanetary Society

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(A photocopy of this form may be submitted)

I apply for Membership which will include a subscription to *Spaceflight* and one of the following special offers:

- a voucher worth £5 off the price of any title in the BIS Video Collection ☐*
or an official Society pin-on lapel badge ☐†
or a copy of the book by Robert C. Parkinson "Citizens of the Sky" ☐†

- I enclose (a) £38 (US\$69) for a 12 month subscription from January-December 1995 ☐
(b) £57 (US\$103) for an 18 month subscription from July 1995 to December 1996 ☐

Reduced rates are available for those under 22 or of 65 years or over. For (a) the amount is £26 (US\$47). For (b) the amount is £39 (US\$71).

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(Print with surname first)

Postal Address Date of Birth

Professional Affiliation Job Position or Title
& Address (if applicable)

Signature Date

*Application constitutes
acceptance of
the Society's
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Spaceflight



The International Magazine of Space and Astronautics

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* * *

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SPACE LAUNCHER
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Mir Rendezvous

STS-63 Mission Highlights

Launch Date: 3 February 1995

The 20th orbital flight of Discovery. The crew included as mission specialists Russian Vladimir G. Titov, Janice Voss and British born C. Michael Foale. The prime objective of the mission, and the first stage in the American-Russian space station programme, was to make a close rendezvous with MIR to test the procedures to be used on Mission STS-71 to dock the shuttle with the space station. STS-63 carried Spacehab-3 science module and the SPARTAN-204 deployable/recoverable astronomy satellite. Other experiments included CSE (Cryo Systems Experiment), GLO-2 (Shuttle Glow Experiment), ODERACS-2 (Orbital Debris Radar Calibration Spheres). The video runs for approximately 1 hour and includes some spectacular rendezvous images of the MIR space station.

STS-65: Mission Highlights

Launch Date: 8 July 1994

STS-65 was the 17th trip into space made by space shuttle Columbia which spent 14 days in orbit. The mission conducted a wide range of experiments concerned with biochemical, biological and human physiological processes in reduced to zero-gravity environments. The science crew included for the first time a Japanese woman as a mission specialist. The second International Microgravity Laboratory (IML2) science programme was made up of a number of experiments ranging from protein separation and electrophoresis, to the study of growth and breeding of fruit-flies in zero to 1G variable-gravity environments. The effects of zero-G on the swimming orientation of goldfish, and the behaviour of adult Japanese Red Bellied newts and the growth of their embryos were among a range of aquatic experiments performed in a special unit called the AAEU (Aquatic Animal Experimental Unit) which was probably the first equivalent of an aquarium in space. The video includes some excellent views of Earth. There is only a limited sound commentary.

57 mins

Postage & Packing per cassette: £1.25 in the UK.
£2.50 (US\$5) surface mail overseas. £3.75 (US\$7) airmail.

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For a complete list of the BIS Video Collection write to The British Interplanetary Society, enclosing a sae.

Tapes are VHS PAL format only. They are NOT compatible with US NTSC system. Please check that your equipment is compatible before ordering.

Allow 28 days for delivery in the UK & six weeks overseas.

STS-64: Mission Highlights

Launch Date: 9 September 1994

The 19th flight of Discovery conducted a diverse range of experiments concerned with Earth environment monitoring technology. The mission included the release and recovery of the 2800 pound SPARTAN satellite. The mission included extended EVA activities. Nitrogen propellant recharging of the astronauts' manoeuvring unit, the SAFER (Simplified Aid for EVA Rescue), is shown. Its manoeuvring ability and its attitude control system are impressively demonstrated. The mission also included a series of atmosphere monitoring experiments with the Lidar in Space Technology Experiment (LITE) instrument.

1 hr 4 mins

STS-60: Mission Highlights

Launch Date: 3 February 1994

This Discovery mission included Russian cosmonaut Sergei Krikalev and marked the start of a new era of USA and Russian cooperation in Space. The mission carried the Spacehab module and a three-dimensional gravitational accelerometer. Other experiments included the study of crystal growth under zero-G, the deployment of BREMSAT and the launch of six Orbital Debris Radar Calibration Spheres (ODERACS), ranging from 5 to 15.2 cm in diameter.

58 mins

STS-59: Mission Highlights

Launch Date: 9 April 1994

Perhaps the most challenging part of this shuttle mission was experiment SRL1, the first flight of the Space Radar Laboratory. To study the surface of the Earth with this instrument package Endeavour was required to make more than 400 separate position manoeuvres to achieve the ground track and orbiter alignment essential for radar mapping the surface and geology of the Earth. Other important tasks included tests of a new form of video-microscope capable of studying biological processes, such as cell growth and movement, under zero-G conditions. Pollution studies included mapping the global and local distributions of CO important in the study of ecology and the ecosphere. There are a number of spectacular SRL1 Earth views.

59 mins

Please send me the following cassette(s): Please Tick

- | | | |
|---|--------|----------|
| ☐ Space Shuttle: A Remarkable Flying Machine | £11 | (US\$20) |
| ☐ Challenger: Accident Investigation | £11 | (US\$20) |
| ☐ STS-26: The Return to Flight | £15 | (US\$27) |
| ☐ STS-31: The Hubble Deployment | £15 | (US\$27) |
| ☐ STS-32: The Recovery of LDEF | £15 | (US\$27) |
| ☐ STS-37: Video Highlights | £15 | (US\$27) |
| ☐ STS-37: Post-Flight Press Conference | £15 | (US\$27) |
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| ☐ STS-46: Mission Highlights | £15 | (US\$27) |
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An Incremental Approach to Mars Exploration

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Front Cover: The WIND spacecraft was launched in November 1994 to study the solar wind over the next two years and is the first of two missions in NASA's Global Geospace Science (GGS) program. The second is to be launched in November 1995. See p.300 for the full story by Roger G. Guillemette, courtesy of whom the front cover illustration is supplied.

MARTIN MARIETTA

Space Transportation

Services and New Technologies in Worldwide Competition

The full-scale mock-up of Ariane 5, which dominated the Paris Air Show 95, typified the main topic of astronautics during this international aerospace event, namely that of space transportation services. Major announcements were made by Lockheed-Martin and Khrunichev, by Arianespace, by ESA, by SEP, by Aerospatiale, by DASA (Daimler-Benz Aerospace) and by Pratt & Whitney. A lot of launch vehicles were exhibited or depicted inside the Russian-Ukrainian pavilion, on the stands of French Aerospatiale, and of American Boeing and Rockwell. China, Brazil, Israel and Spain presented their ambitions in space technology.

The main absence to be regretted was the International Space Station Alpha due to a lack of interest from European countries. Boeing, as prime contractor, exhibited a small mock-up of Alpha, while Khrunichev showed a nice little mock-up of the FGB (Functional Cargo block), the first element of Alpha.

Ariane 5 Evolution

ESA Director General Jean-Marie Luton, in referring to the challenging decisions to be taken at the Ministerial Conference at Toulouse in October, insisted on the role of Ariane 5 for Europe in space, and also on the post-Ariane 5 development with the

The Russian FGB (Functional Cargo Block) for the International Space Station Alpha.



The Arianespace Pavilion at the Paris Air Show.

ARIANESPACE

BY THEO PIRARD

Belgium

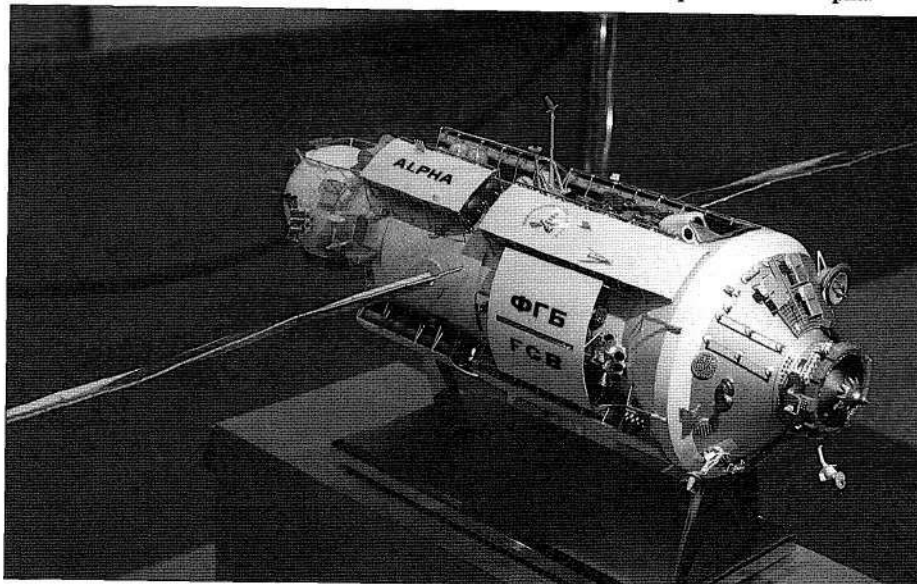
Ariane 5 Evolution and ARTA programmes. The aim of the Ariane 5 Evolution programme is to develop an upgraded launch vehicle with a 20% increase in GTO performance by the year 2001. Ariane 5 Evolution will be able to offer dual launch of satellites

with a mass of 3.5 to 3.7 tons each.

The first model of Ariane 5 Evolution calls for these improvements:

- Use of a small and light fairing and structure for dual launch - the SPILMA structure in composite materials instead of the SPELTRA - will allow an increase of 300-400 kg in GTO performance;
- Welding, instead of the heavy bolting, of the solid booster elements will represent a mass saving of 1,900 kg per EAP (Etage A Poudre) and upgrade GTO performance by up to 150 kg;
- EPC Evolution (Etage à Propulsion Cryotechnique) will consist of a new configuration of tanks inside the cryogenic core stage with a more powerful, Vulcain Mk 2 engine providing the most significant upgrade: a further capability of 800 kg in GTO!
- The "made in Germany" upper stage or EPS (Etage à Propergols Stockables) will have larger tanks and the Aestus engine will develop a specific impulse of 35 kN instead of 27.5 kN. This optional upgrade, to be introduced between 2001 and 2005, will allow an extra 400 kg to GTO.

The Ariane 5 Evolution programme is estimated to cost a further 1.2 billion Ecus or \$1.6 billion (equal to a



quarter of the Ariane 5 programme) between 1996 and 2001. Some ESA Member States consider the current Ariane 5 as already very powerful and this new investment to upgrade such a heavy launch vehicle is a matter under discussion. Germany is reluctant to invest further money in a new development of Ariane 5 as the German aerospace industry is mainly concerned only with the upper stage and the Aestus engine. Arianespace, however, is pressing ESA and European industries not to stop development efforts initiated with the Ariane 5 programme and to go ahead with a continuous effort through the Ariane 5 Evolution Programme in order to keep in service most of the existing teams working on Ariane 5 development. Also, the use of Ariane 5 launch vehicles in the exploitation of the International Space Station Alpha requires an improved version for operations with the ATV (Automated Transfer Vehicle).

Europe

On 10 June, Arianespace signed a \$2.4 billion contract with European industries for the first batch of 14 Ariane 5 launch vehicles, to cover its needs until the year 2000. This contract is only a beginning which is expected to lead to a second batch of 50 launchers. The first commercial Ariane 5 will be 503 to be launched in late 1996. Until late 1998, there will be a transition phase during which both Ariane 4 and Ariane 5 will be simultaneously available to meet the requirements of customers. For this transition, five further Ariane 4s have been ordered from European industry, bringing the total of the first generation of Ariane launch vehicles to 104.

France

CNES (The French Space Agency) and the French space industry generally are pressing for the European development of a small launch vehicle for light satellites. A project currently under evaluation involves a European Small Launcher (ESL) able to place 1 t in a 700 km circular orbit. The targeted launch cost of under \$20 million should make the launcher a very attractive solution to lightsat launch operations.

The French space industry, as well as pushing for the Ariane 5 Evolution, is also pushing for a small launcher to be developed within Europe and/or with Russian or Ukrainian firms. Aerospatiale is proposing the ESL (European Small Launcher) and the ESLM (European Small Launcher Medium). Roger Vignelles, Chairman and Director General of SEP (Société Européenne de Propulsion), as well as François Calaque, Head of Space Activities at Aerospatiale, Les Mureaux, both say that by late this year, Euro-



Arianespace signed contracts on 10 June 1995 with European industries for an initial batch of 14 Ariane 5 launch vehicles. From left to right: Messrs. de Valence (Clemessy), Schneiter (Contraves), Carlier (Matra Marconi Space), Mingoli (Europropulsion), Gallois (Aerospatiale), Bigot (Arianespace), Heinzmann (DASA), Vignelles (SEP), Fuentes (Casa) and Gérard (Cegelec).
ARIANESPACE

pean industry has to take the initiative with the development of an ESL-type vehicle in order to meet the launch needs of year 2000.

Arianespace Confident

Charles Bigot, Chairman and Director General of Arianespace, said that he was confident in the future of Ariane 5, which will begin its commercial career in late 1996:

"...taneously 24 satellites of the Globalstar constellation!"

But he saw a more promising market in the launch of big satellites in GEO than in the launch of light and small spacecraft:

"In the near future Arianespace has no reason to enter the market of lightsat launches with a specific launcher."



Ariane 5 and the European Small Launcher (ESL) which is under evaluation.

"This is the first born of a new generation which will subsist for 40 to 50 years. The investment of 6 billion Ecus for its development will be followed by utilisation at the rate of 5 to 7 launch vehicles per year. This will represent a production of 300 to 350 units with an average revenue of 120 million dollars per launch for European industry. Ariane 5 is designed to offer the possibility of upgrading it by 10 to 20%, even to 40%, with the development of derivatives, namely Ariane 6 or 7."

Charles Bigot did not exclude an opportunity to place mini-satellites in LEO constellations with a single Ariane 5 launch:

"Ariane 5 will be able to launch simul-

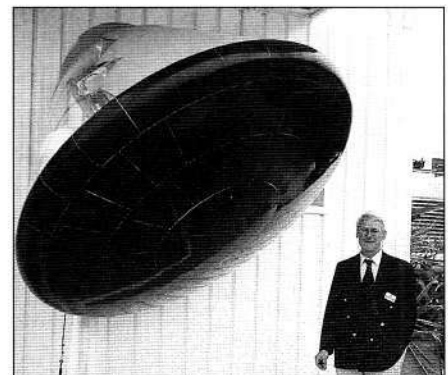
Charles Bigot had several points to make about international competition, referring to the new alliance of Lockheed-Martin and Khrunichev as a direct and strong threat to the European space industry. He regretted the lack of support from European countries when their contracts went to non-European launch services [the contract of DASA for Nahuelsat 2 with a Chinese Long March 3C launch vehicle]:

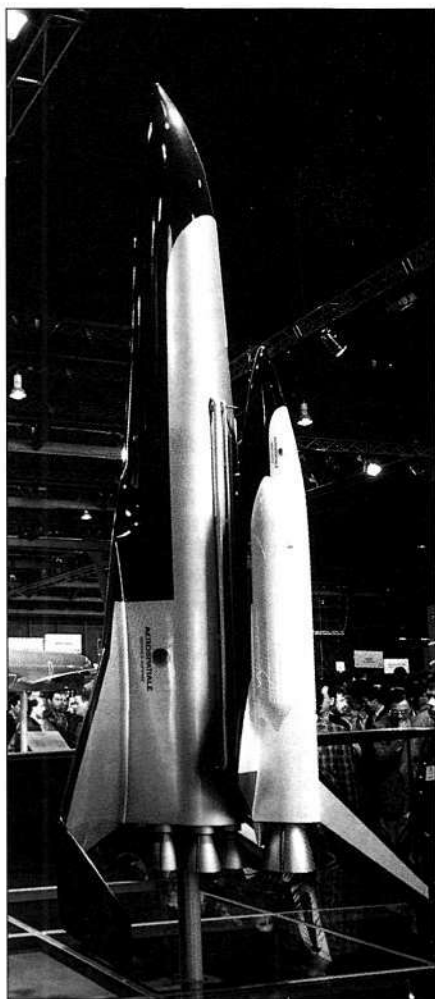
"It would be beneath everything to go to Chinese rockets after being successful with the establishment of European launch services!"

He summarised the American scene as follows:

"They get the support of the US government through military contracts. The development of the EELV (Evolved Expendable Launch Vehicle) offers the best prospect of improving their existing capability. Lockheed-Martin and McDonnell Douglas are candidates in the competition for the EELV programme, respectively offering up-

The first recoverable spacecraft of ESA, ARD (Atmospheric Re-entry Demonstrator), to be tested on Ariane 502.





Looking to the future. An Ariane 6 Model on display.

graded versions of the Atlas-Centaur and of the Delta vehicles. The company which wins the EELV contract will dominate the market of launch services in GTO. Hughes which competes with Lockheed-Martin in the field of communications satellites would not like to see a monopoly for the technology of communications and broadcasting satellites in the hands of its direct competitor. That is the reason why Hughes has decided to support the Delta 3 proposal."

Additional information was given by Patrice Larcher, Marketing Manager of Arianespace, about the EELV contract:

"It seems that the US Department of Defense has finally decided to go ahead with the programme to upgrade its fleet of launch vehicles, but the question is to know in what manner the new system has to be a fully American one. Europe has to show interest in this venture and this is the reason why Charles Bigot is placing Arianespace, leading the European industry, as a partner in the development of the EELV. We are associated with Alliant [the ex-Hercules Aerospace company] to propose an Ariane-5 type launcher for the EELV programme. Among the possible candidates for the RFP currently in progress against whom we expect to compete are Lockheed-Martin with an upgraded Atlas, McDonnell Douglas with Delta 3 and Boeing with a modernised Ukrainian Zenit."

Spain

INTA (Instituto Nacional de Técnica Aeroespacial) is working on a lightsat launch vehicle (the Capricornio programme) and on mini-satellites (the Minisat programme).

The Capricornio launch vehicle is taking form in three phases. According to Ricardo Dorado Gutierrez, Adjoint Director General of Programmes at INTA, these are:

- Phase I, which has been successfully completed, marked the development of solid motors for the I-100 and I-300 sounding rockets, launched from the Huelva test range in the south of Spain.
- Phase II, which is in progress, will see the test of a technological demonstrator with the two-stage Argo sounding rocket; this 9.2 m long rocket, 0.83 m in diameter, will use the second and third stages of the Capricornio launch vehicle. The first flight of Argo is planned to take place in August 1996.
- Phase III will be the final development of Capricornio with a first test flight during Summer 1997. The three-stage launch vehicle, 18.2 m long and 1 m in diameter, has a lift-off mass of around 15 tons. It will be launched from the Island of El Hierro (27° North) in the archipelago of the Canaries to place satellites of up to 100 kg in low orbit.

The first payload will be a "made in Spain" technological microsatellite to collect and relay data from the Spanish base in the Antarctic; it will be developed by the Centre of Micro-electronics at Barcelona.

INTA, which depends on the Ministry of Defence and whose space activities are again picking up after a shutdown in late 70s (after the death of General Franco), is acting as the prime contractor for Capricornio. A group of Spanish industries - UEE, INSA, Ceselsa, Expal, Santa Barbara and CESA - is developing the launch vehicle. The total budget of the three phases of the Capricornio programme is some 4.5 billion pesetas or \$32 million.



Spain in space: Capricornio, the launch vehicle for light satellites.

Launch vehicles under development or evaluation by the French space industry. © June 1995 - Space Information Center

Details	Ariane 5	Ariane 5 Evolution	ESL	ESLM
Configuration	H155 / 2 x P230 + L9.7	H170 / 2 x P230 + L15	P50A + P50B + P7	P230 + P50B + P7
Height	45 - 55.9 m	45 - 55.9 m	27.4 m	48 m
Mass at launch	710 - 718 t	740 t?	120 t	338 t
Mass in orbit	5.9-6.9 t / 10 t / 18 t	7 - 7.4 t	1 t	3.8 t
Type of orbit	GTO/SSO/LEO	GTO	SSO at 700km	SSO at 700 km
Fairing diameter	4.5 m	4.5 m	2.2 m	3.65 m
Announced price	\$130 million	NA	\$20 million?	\$40 million?
Operator	Arianespace	Arianespace	Arianespace?	Arianespace?
Actual status	1st demonstration flight in January 1996	ESA decision in October 1995 for 1st flight in 2001?	To be decided in late 1995 for 1st flight in 1999?	To be decided in late 1996 for 1st flight in 2000?

USA

American space industry was represented at the Paris Air Show by Lockheed-Martin, with its application satellites (Astro Space), LLV rockets and the Proton and Atlas launch services. Modest presentations of space transportation systems were made by Boeing with Sea Launch and Rockwell with small X-34 and X-33 mock-ups.

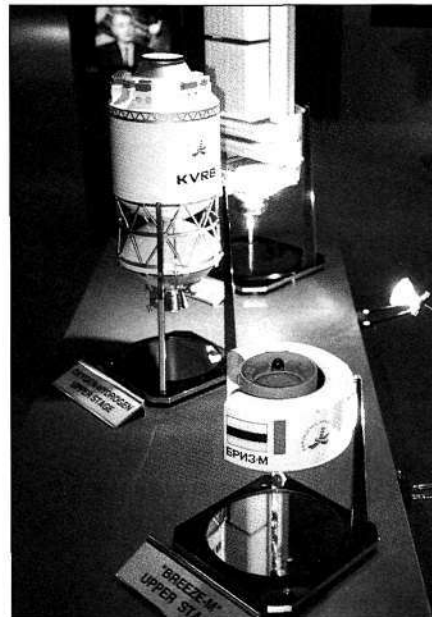
Lockheed-Martin, Khrunichev Enterprise and RSC Energiya

The establishment was announced of the new alliance ILS (International Launch Services), which is to be responsible for the joint production and marketing of Proton and Atlas launch vehicles. ILS aims to give a high assurance of on-time delivery in orbit with reliable and flexible launch services, based on two different vehicles. During the press conference of Dr Vance D. Coffman and Anatoli I. Kiselev, the two co-chairmen of the new company, some interesting facts were stated:

- The technological challenge for customers is to make spacecraft compatible with both Proton and Atlas. "The Hughes HS-601 will be the first payload to fly aboard Atlas/Proton: [also with Chinese Long March!]"
- The commercial launch manifest of Proton, within the ILS agreement, concerns up to 12 satellites before year 2000. The first commercial launch of Proton is planned for 1 March 1996 to carry the Astra 1F broadcasting satellite to GEO (for Luxembourg-based SES). There are already contracts with Hughes for Astra, Loral for Tempo, with PanAmSat, with Inmarsat, and with Iridium.
- The difference of prices between Atlas and Proton is not very great. The price to lease the facilities at Baikonur and to use the services of the Russian Space Forces has yet to be fixed and would be the subject of the next Council of ILS.
- The ILS agreement concerns upgraded versions of Atlas as proposed for the EELV programme of the Department of Defense and of Proton which is getting improvements in two ways with:
 1. A storable Breeze-M upper stage in 1998 which is an upgraded version, with additional tanks, of the upper stage for the Rockot vehicle to achieve 3.2 tons in GEO (instead of 2.6 tons with the existing Block D upper stage). Its development started one year ago and its first test flight will be made in 1997.
 2. A cryogenic upper stage named OHSM (Oxygen-Hydrogen acceleration module) and propelled by the KVD-1 engine of Khimmach after the year 2000 to put up to 4.5 tons in GEO (to compete directly with Ariane 5). Its development began in 1993 and its first test flight is announced for 1998.
- LKEI, for ILS, is investing money to modernise the infrastructure at Baikonur to enable use to be made of



Dr Vance D. Coffman and Anatoli I. Kiselev, the two co-chairmen of the newly-formed company ILS (International Launch Services), at their press conference.



The two upper stages of the improved Proton: (1) the Breeze-M upper stage (below) and (2) the oxygen-hydrogen upper stage (above).

the Jubilee runway (planned for the Buran space plane) by Boeing 747 aircraft, to provide clean rooms, to upgrade the power station to satisfy customers' technical requirements, and to

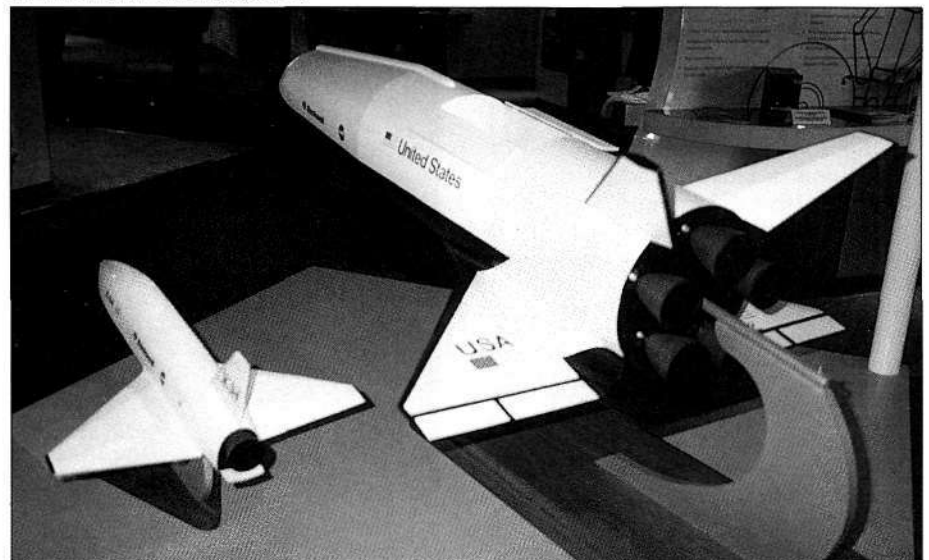
provide Western-class accommodation for non-Russian technicians, direct links with the Intelsat system and some launch table upgrades. The modernised facilities will be ready later this year in time for Proton's first commercial payload.

Lockheed-Martin

The company's LLV family of solid launch vehicles is able to place spacecraft of 1 to 4 tons in LEO. LLV-1, which is able to put 1 ton in LEO, uses the Thiokol Castor 120 solid motor as the first stage and an Orbis 21D of United Technologies Chemical Systems Division as the second, plus the Orbit Adjust Module, housing attitude-control systems and avionics. LLV-2 will be a three-stage vehicle, using another Castor 120 motor as the second stage. LLV-3, still in the planning stages, would have four configurations, depending on the number of strap-on boosters used (from 2 to 6) and they remain attached to the first stage after burnout.

The first flight of the LLV-1 Demonstration Launch Vehicle - the first booster to lift-off from Vandenberg's Space Launch Complex (California) - was scheduled for July to place in a 650 km near-polar orbit the 130 kg

Rockwell's proposed successors of the space shuttle: the X-33 (for heavy spacecraft) and the X-34 (for small payloads).



GEMstar communications satellite developed by CTA Space Systems (McLean, Virginia) for VITA (Volunteers in Technical Assistance); GEMstar will test global data communications for both CTA and VITA.

Boeing Commercial Space Company

'Sea Launch' is an international joint venture of the company with Russian RSC Energiya, Ukrainian NPO Yuznoye and Norwegian Kvaerner and its aim is to provide a reliable and cost effective launch alternative with the launch of up to 5.9 t in GTO (the performance of Ariane 5!):

- Kvaerner brings its experience in developing off-shore oil platforms and will design and construct the launch platform and the command ship and perform marine operations.
- NPO Yuznoye will provide the two-stage Zenit to be launched from the off-shore platform; it offers the advantages of automated checkout and launch operations, and of ecologically clean propellants.
- RSC Energiya provides the automated support equipment and the Block DM third stage with restartable engine (of 97% demonstrated reliability).

For LEO and polar orbit launches, the operations will take place between Hawaii and the West Coast (California); GTO and GEO launches will be made between Hawaii and Christmas Islands, close to the equatorial line. First launch of Sea Launch Zenit is planned for 1998. Boeing will manage the project.

Russia

A plethora of expendable launch vehicles - up to 10 different systems - were on the stands of the Russian and Ukrainian space industries. The presentation revealed an impressive know-how of space rocketry in the ex-USSR. Even so, RKK Energiya missed this opportunity to exhibit its spacecraft and know-how in orbital operations. The new cryogenic KVD engine of KB Khimmach for the upper stage of Proton, which is derived from the engine sold to India for the Indian GSLV, was presented.

Khrunichev State Research and Production Space Centre

This was a most important and impressive stand exhibiting a lot of new products and services. It presented the availability of three launch vehicles: the Rockot, the Proton (with its new upper stages to upgrade it) and the revolutionary Angara. Animated mock-up launch platforms of Proton and of Rockot attracted great interest.

Also presented was a mock-up of a 200 kg mini-satellite developed by Surrey Satellite Technology Ltd (SSTL, United Kingdom) and having the remote sensing capability of the first Landsat (i.e. 30 m resolution multi-

spectral pictures). The satellite will be launched in October 1996 by a three-stage Rockot - the last one to be fired from a Baikonur silo.

The Angara vehicle is based on a new revolutionary concept of suspended tanks. It is propelled by ecologically clean engines, developed and produced in Russia, the first stage using the four-chamber RD-174 of Energomash, which is derived from the RD-170 engine of the Zenit first stage, the second stage using a cryo-



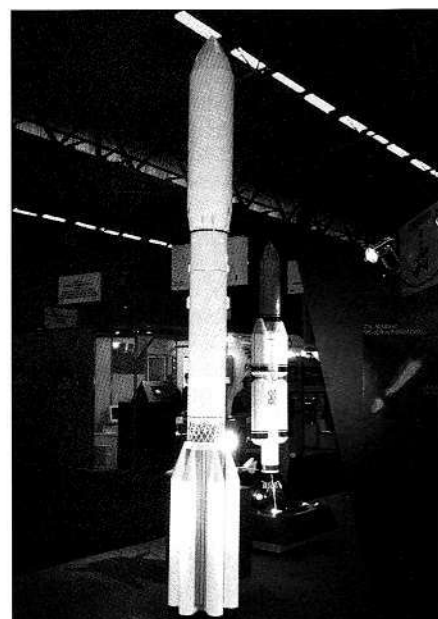
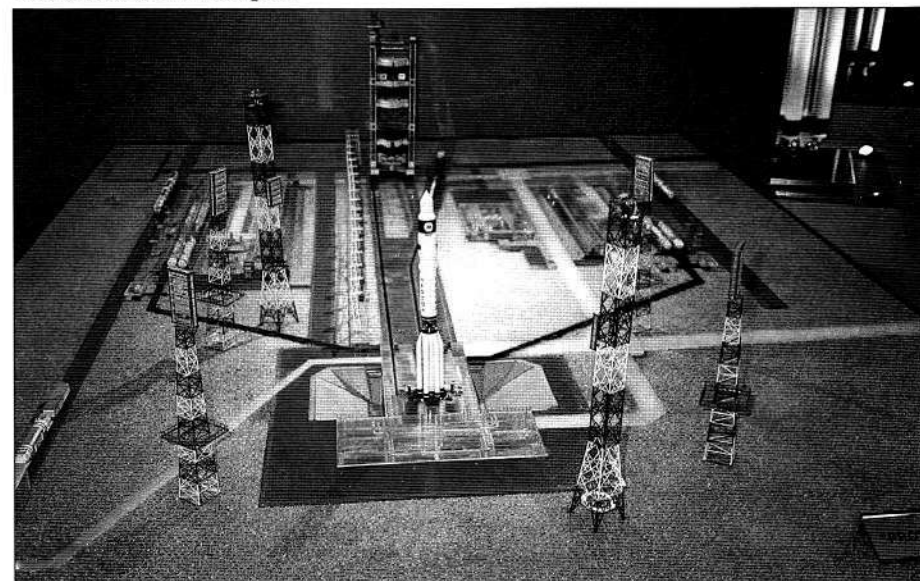
The new cryogenic KVD engine for the upper stage of Proton.

genic engine which could be the KVD-1M of Khimmach.

Angara will be available for military operations from the Zenit launch pad at Plesetsk cosmodrome between 2000 and 2002 and will be capable of placing 26 tons in LEO or 4.5 tons in GEO.

Khrunichev, the prime contractor, announced that in the future the first stage will be transformed into a reusable one having the capability of returning to the launch pad.

In cooperation with the Molniya Enterprise, an air-launched Angara system. The Proton launch complex.

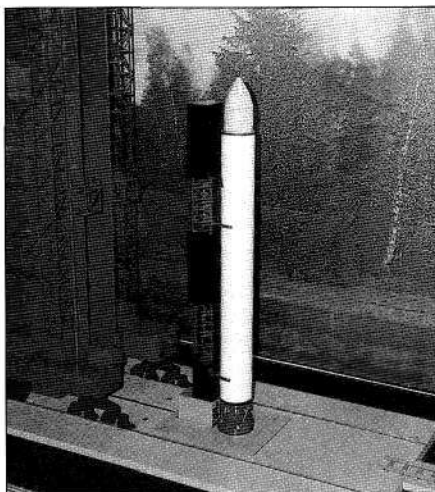


The improved version of Proton to be available in the late 1990s. In the background is Russia's new Angara vehicle.

tem or the aero-rocket complex (ARC) is proposed using the giant Antonov An-225 as a first stage to transport a modified Angara second stage. ARC is described as capable of placing up to 6 tons in LEO for less than \$1,500 per kg.

Russian Space Agency (management of the Russian space programme) and Russian Space Forces (management of the Russian launch services)

Each had a small stand to explain their respective role in the new organisation of the space activities in Russia. On panels, with videos and leaflets, the Russian Space Forces described the cosmodromes of Plesetsk, of Baikonur (for manned space flights) and of Svobodny. They promoted the use of nine types of launch vehicles: Molniya-M, Soyuz-U, Soyuz U2, Tsyklon-2, Tsyklon-3, Cosmos-3M, Zenit-2, Proton-K, Rockot. These will be replaced by modernised rockets:



A mock-up of the Rockot launch system.

Vzlet (from the Cosmos rocket) in 1998, Rus (from the Soyuz rocket) in 1997, Proton (with Breeze-M upper stage) in 1998, Angara after the year 2000.

Lavochkin Association

This specialised firm in the technology of planetary probes and applications was promoting the versatile interorbital tug Fregat. This restartable (up to 20 times) tug will be operational in 1996. It is proposed for orbital operations as the third stage of the Vostok-2, the fourth stage of the Soyuz-2 (2.5 tons in GTO), the third stage of the Zenit-M (2.5 tons in GEO), the fifth stage of Proton-M (3.5 tons in GTO).

The Molniya Scientific and Industrial Enterprise

Know-how in space plane technology is being pursued through the MAKS project (the Multipurpose Aero-Space System). An international consortium has been established as a joint-stock corporation for the development of the two-stage complex consisting of the Ukrainian Mria An-225 aircraft carrying an outboard tank with a manned orbiter or a cargo container. Total cost of the project for the development of MAKS is estimated to be around \$3.5 billion. According to Molniya information, a technical potential of \$1.5 billion has been created and the Ukraine is investing some \$300 million in the venture. Negotiations are in progress with a number of firms in France, US, Japan, Kazakhstan and South Korea.

NPO Energomash

The ecologically-safe propellant two-stage Riksha-1 rocket is designed to launch up to 1.7 ton in LEO. The 64 t launch vehicle is based on the use of available technologies: it is propelled by six RD-169 engines in the first stage and by a single RD-185 engine: both engines use liquid oxygen and liquefied natural gas as propellants. The announced cost for its three-year development is \$135 million. Each Riksha launch would cost \$10-11 mil-

lion: 1 kg payload in LEO would be around \$8000. The first commercial flight is planned for 1999 from Plesetsk or from an equatorial site.

Glavkosmos

The conversion of military technology towards civilian use and for export is favoured by this organisation. Glavkosmos promoted with a video the commercial services of a sea launch vehicle, Surf, which is developed by the State Rocketry Centre Makeev. The 104 ton Surf rocket has five stages and it is designed to place 1.8 to 2.4 tons in LEO. The test launch of a demonstration vehicle is planned to take place in September 1996. It is launched directly from the water surface without a platform.

Cooperation with Germany

DASA (Daimler-Benz Aerospace) of Germany and the Khrunichev State Research and Production Space Centre have formed a joint venture to offer worldwide cost effective launch services for the rocket launch system, being marketed as Eurockot launch Services GmbH. The first flight of the three-stage launch vehicle, which will be able to place from 300 to 1,800 kg in LEO with high accuracy (using the Breeze upper stage) was announced for 1997 from a modified Cosmos launch pad at the Plesetsk cosmodrome.

The air-launched Diana-Burlak system, which would be approved for funding by German space agency DARA in late June is a two-liquid stage booster, to be launched from an airborne Tu-160 CK. The Russian partners in this joint venture are MKB Raduga, OKB MEI and Tupolev and the German partners are DARA, OHB System and STS Systemtechnik Schwerin. It would use liquid engines developed by KB Khimautomatika. Development could begin during this summer aiming at a first test flight during 1998. Diana-Burlak would be able to place 1.1 ton in LEO at less than \$5,000 per kg.

Ukraine

Yuznoye Mashinostroitelny Zavod had a very modest stand to explain its considerable expertise in space technology and applications. It presented real elements of rocket systems and mock-ups of the Cyclone and Zenit 2 vehicles, along with the mock-up of "made in Ukraine" spacecraft: the 2.3 ton AUOS platform for solar observations and the 6.7 ton Sitch radar satellite for remote sensing operations.

Brazil

The Agencia Espacial Brasileira (AEB) had a nice stand presenting Brazil in Space. For Dr Ajax Barros de Melo, Director General of AEB, 1996 appears to be the great year for the future of the Brazilian space activities: it will be marked by the first test of



The design of the two-stage launch vehicle, Riksha, is being studied by Energomash.

the indigenous VLS launch vehicle and by the launch of the first China-Brazil Earth Resources Satellite (CBERS-1).

The first launch of the VLS launch vehicle is planned to take place from Alcantara in July 1996. The four-stage solid rocket, 19.5 m long with a launching mass of 50 tons, will be able to launch up to 185 kg into a 750 km circular orbit. The payload for this first qualification flight will be a SCD-type spacecraft, but delays in budgetary allocations for 1995 may postpone this launch until late 1996 or early 1997.

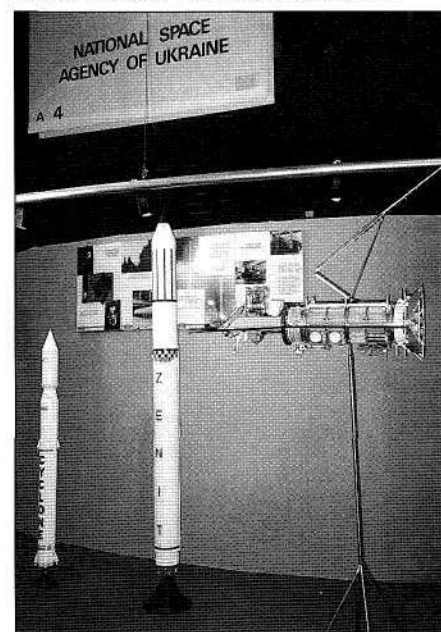
China

Models of the Long March family of launch vehicles were exhibited including the recent addition of Long March 3C with two strap-on boosters. ■

(Photo Credits: Th.PIRARD/SIC except where otherwise stated.)

(Details of the Long March family are provided by Hornuz P. Marna on the following pages.)

Mock-up of Ukraine's Cyclone and Zenit launch vehicles and the Sitch-1 radar.



China's Long March

BY HORMUZ P. MAMA

Bombay, India

As China strives to increase its share of the international space launch market, we look at the technical details and capabilities of its current family of Long March launch vehicles. The illustrations in this article were released at *Asian Aerospace* held in Singapore in February 1994 and the accompanying descriptions are based on interview material obtained by the author.

LM-1D (lower left)

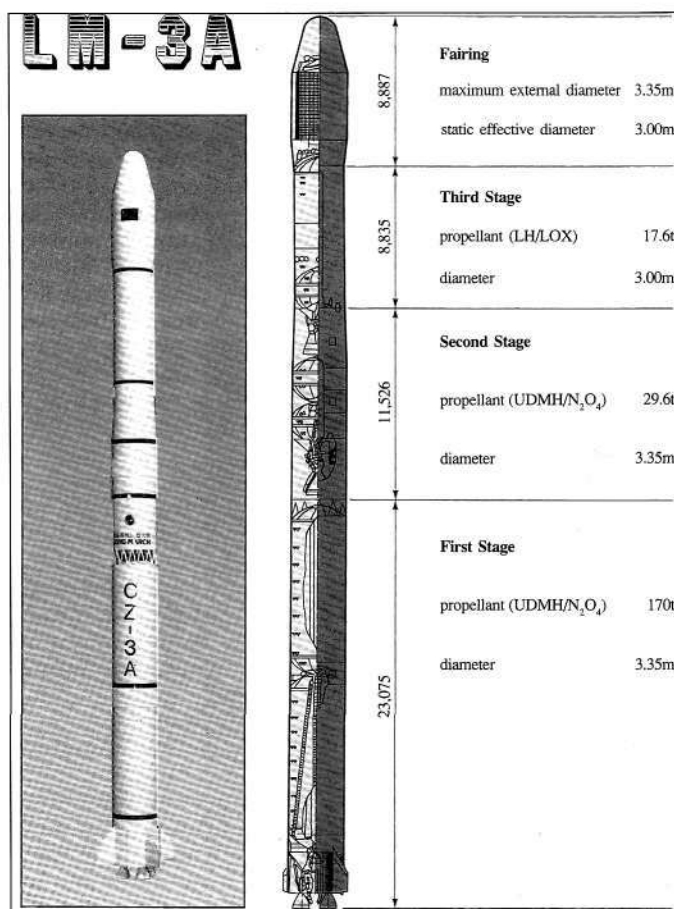
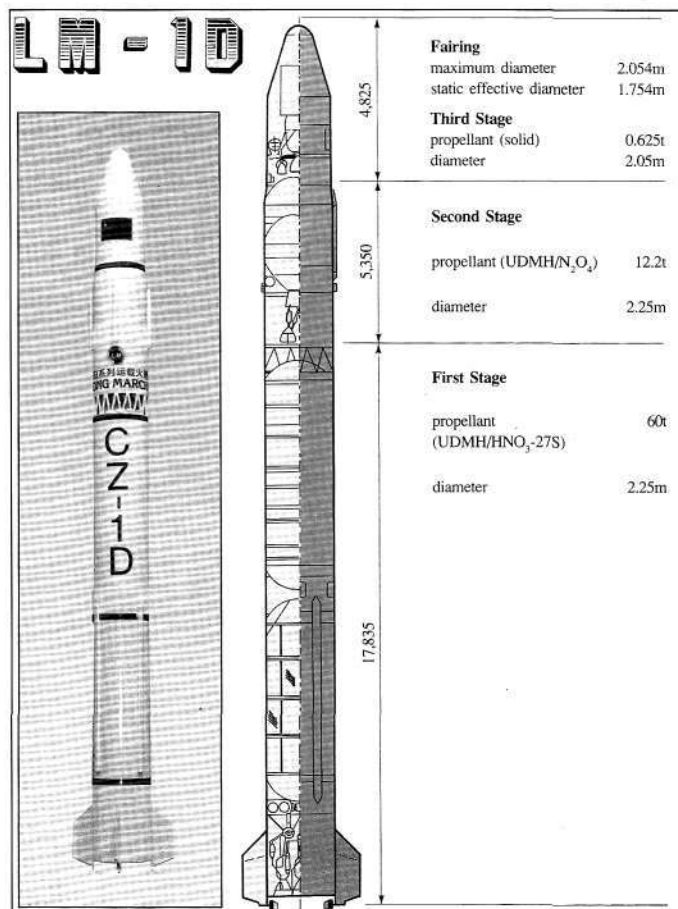
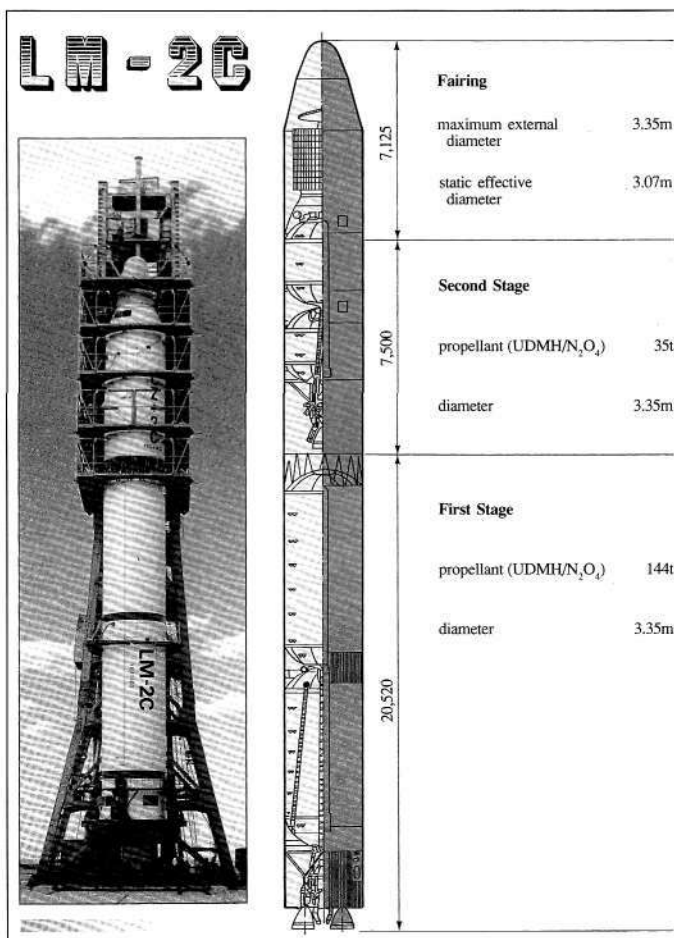
Latest in the family to be announced to date is the LM-1D, to be in service from 1996. A development of the LM-1 that launched China's first satellite, the Dong Fang Hong 1, on 24 April 1970, the three-stage LM-1D has a solid-propellant third stage and storable liquid propellants in the other two. An interesting feature is the use of V-2 type vanes that are deflected in the path of the rocket engines' exhaust gases for thrust vector control.

LM-2C (right)

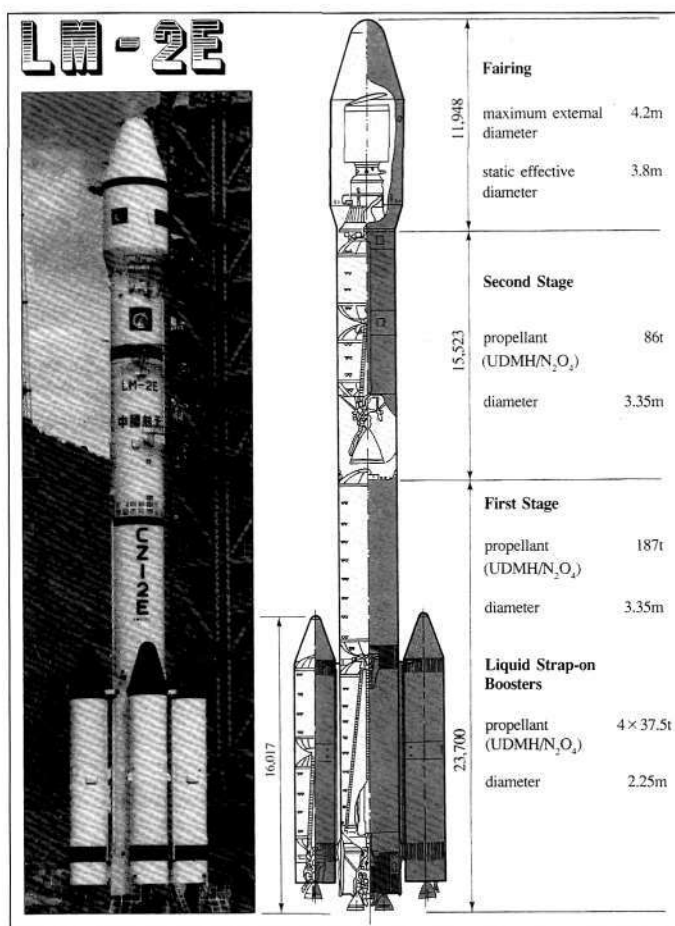
The LM-2C shown on the right was first launched way back on 26 November 1975 to orbit a recoverable satellite. These vehicles have been launched in large numbers, particularly during the 1980s, and will be used to orbit 22 of the Iridium family of communications satellites from 1998 onwards.

LM-3A (lower right)

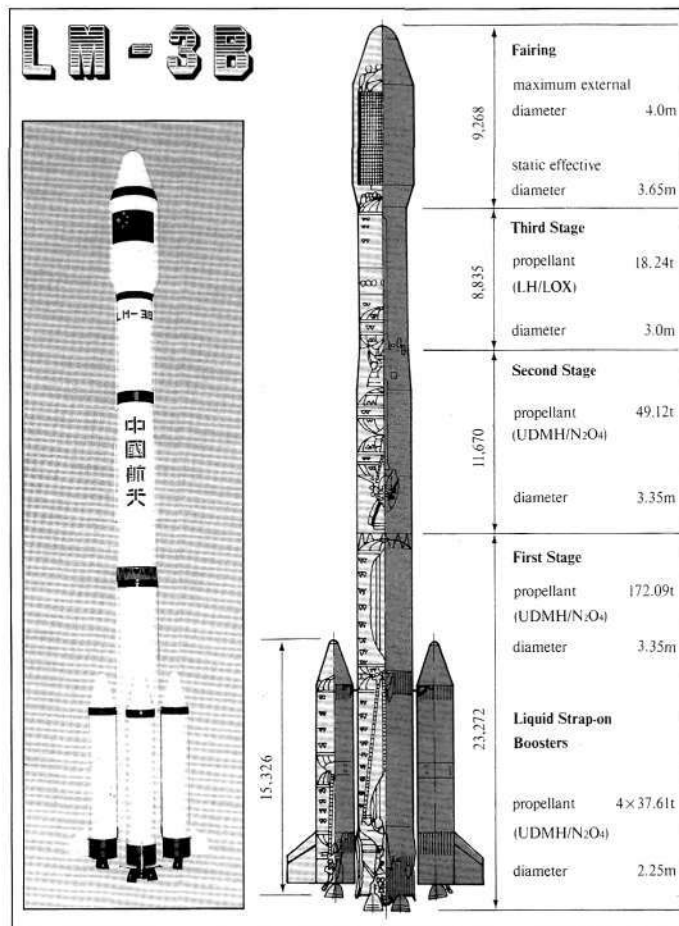
The recently developed second-generation LM-3A had its first launch on 8 February 1994, when it orbited a Chinese scientific satellite. It has a payload of about 2,300 kg to GTO. Its four-chamber Stage 1 engine has a total thrust of 2,962 kN. For Stage 2, the main engine has a thrust of 742 kN and the vernier engine has a thrust of 47 kN.



Family of Launch Vehicles



The LM-2E, with a lift-off mass of 460 tonnes and 9,200 kg payload delivery into low orbit, is by far the heaviest Chinese launch vehicle. The first of these orbited a dummy Aussat B payload and Pakistan's BADR-A (piggyback). The LM-2E has since launched the Hughes-made Optus B1 (the Australian Aussat B1), and B2 in 1992. On 28 August 1994, the LM-2E orbited the Optus B3 satellite from the Xichang launch site in Sichuan and, from the same launch site in January 1995, it exploded in flight with the loss of Apstar 2. The LM-2E's first stage is slightly bigger than that of the LM-3B, while its second stage, with 86 tonnes of propellants, is almost twice as heavy as the LM-3B second stage.

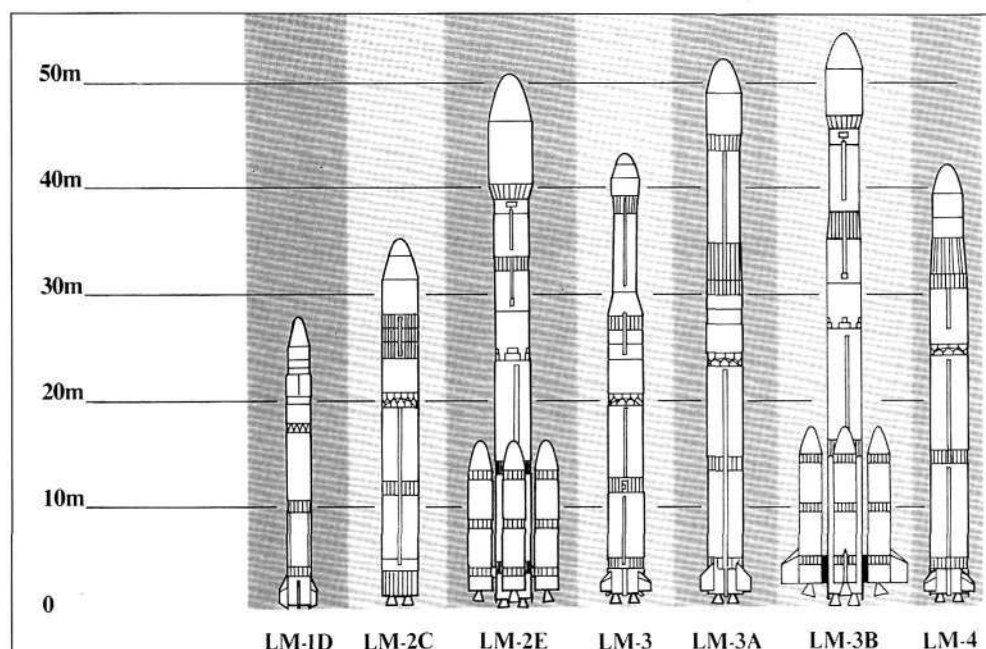


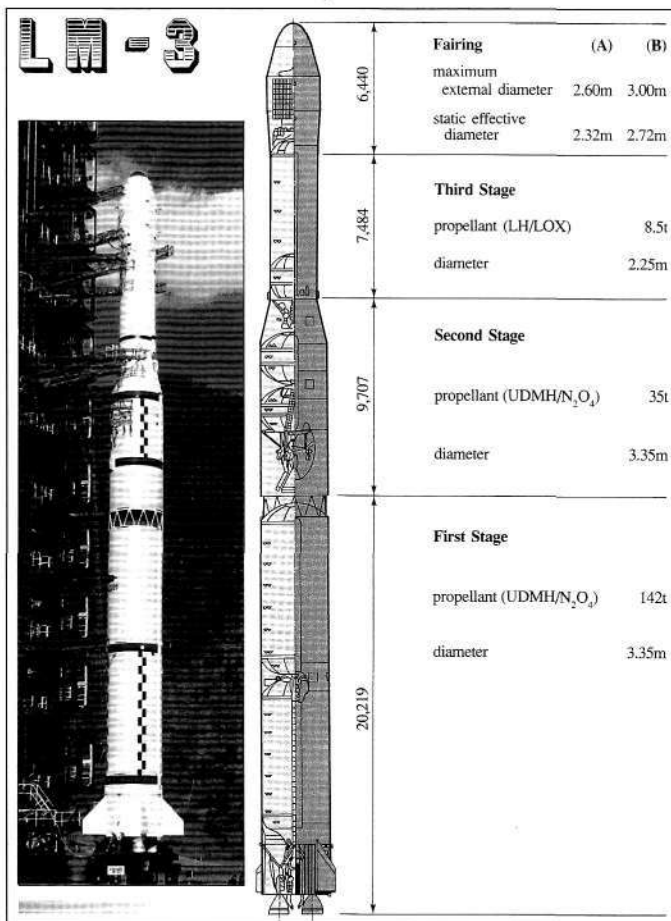
With a lift-off mass of 425 tonnes and a payload of 4,800 kg in GTO, the three-stage Long March LM-3B is to have its first launch between November 1995 and February 1996. Propellant capacity of Stage 2 is to be increased from 29.6 tonnes on the LM-3A to 49.12 tonnes on the LM-3B. While the first two stages have storable propellants, the third stage has cryogenics - LOX/LOH. The biggest difference between the two is the addition of four strap-on boosters using storable propellants. These are also used on the two-stage LM-2E launch vehicle.

The LM-3B has a lift-off thrust of 5,923 kN and a payload mass of 4.8 tonnes.

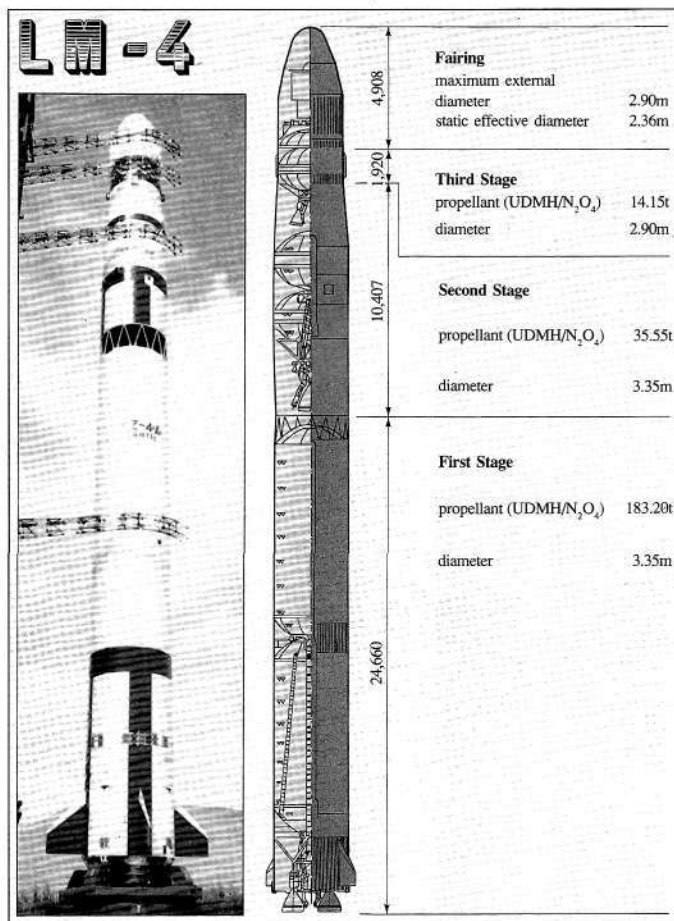
Long March Launch Vehicles

The LM-3 series is notable for its geostationary orbit launch capability.





The LM-3, with 1,500 kg to GTO, was first launched with an experimental satellite on 29 January 1984, and with an experimental geostationary communications satellite in April 1984. On 7 April 1990, the LM-3 orbited the Hughes-made AsiaSat 1.



In service since 7 September 1988, when it had launched a Chinese meteorological satellite, the three-stage LM-4 uses only storable liquid propellants - nitrogen tetroxide/unsymmetrical dimethyl hydrazine.

Vehicle Characteristics and Performance of the Long March Family.

Launch Vehicle	LM-1D	LM-2C	LM-2E	LM-3	LM-3A	LM-3B	LM-4
Overall length (m)	28	35	51	43.85	52.3	54.4	42
Lift-off mass (t)	85	192	460	203	241	425	249
Lift-off thrust (kN)	1,101	2,785	5,919	2,804	2,962	5,923	2,940
Payload capability to low Earth orbit (kg)	750 to 1,000	2,800	9,200				2,500 (SSO)*
Payload capability to geostationary transfer orbit (kg)				1,500	2,300	4,800	
Available for commercial service	1996	1976	1991	1986	1993	1995	1988

*SSO: Sunsynchronous orbit

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Stamps with a Story

Early Philatelic Images of Vostok Left a Lot to the Imagination

When I finally found both the time and motivation to write up my collection of Vostok and Voskhod stamps again I was fascinated by the fact that for the first few years of the space race all the published images of Vostok were totally fanciful. This, of course, was due to the endemic secrecy of the Soviet space programme.

If you study the time gap between the first manned launch and the first issue of stamps by many of the Soviet bloc countries you can deduce the problem that the designers of the first space stamps must have had. The Dutch WEEBAU catalogue gives "12th April '61" (sic) as the issue date of the first Russian commemoratives (SG 2576/8) - that is, the day of the launch. Not much room for delay or use of back-up cosmonaut Titov here! Other "satellite" countries took a little more time, for example Czechoslovakia (13th April), East Germany (18/20th April), Hungary (25th April) and Bulgaria (26th April), whilst others were positively sluggardly, perhaps for political reasons: Albania (15th February '62).

BY JEFF DUGDALE

Elgin, Scotland

others very much so. However, other designers must have thought their brief too silly and resorted to a much more honest approach, using symbolism: see for example, the first stamps for Czechoslovakia ("The Cosmonaut"), Poland and Mongolia ("Red Star in Orbit"), whilst the Rumanian designer solves the problem by putting his



Soviet Union
SG 2981
(12.4.64)

Vostok craft so far in the background it just looks like a blip!

In the intervening months and years before all was revealed one can surmise that some kind of press release went out suggesting what Vostok might look like, with the request "Please use this until further notice". Look at Soviet Union SG 2981 (for Cosmonautics Day 1964), Czechoslovakia SG 1416 (1964), Mongolia SG 347 (1964) and Poland SG 1428 (1963) all of which have a striking similarity of the Vostok design which reminds me of a thimble with a collar around its base. Can this just be coincidence?



Czechoslovakia SG 1416 (27.4.64)

When did the truth first come out then? Space journalist Reg Turnill noted in his Third Edition to the *Observer's Book of Manned Spaceflight* (1978) that "It was four years before pictures of Vostok were released" and James Oberg in *Red Star in Orbit* (1981) goes into much more detail about the secrecy and the deceptions (see his Chapter 4). This is reflected in

About the Author



Jeff Dugdale

Jeff Dugdale has been an English teacher for 24 years and is currently Assistant Rector (Curriculum) at Elgin High School in Grampian. He has no scientific background but has maintained a keen interest in space flight since his teens, as he has done in stamp collecting. A further important hobby of his has been amateur journalism and he has edited monthly school newspapers for nearly 20 years. These three hobbies have recently combined well to allow him to take over as Editor of *Orbit*, the Journal of the Astro Space Stamp Society. This is the closest he will come to getting into "orbit" himself, but he was fascinated by his visit to Cape Canaveral five years ago.

Vostok anniversary and "achievements" stamp designs. The first Soviet stamp to acknowledge what Vostok really looked like is a 10k within miniature sheet SG3929 issued to mark the Tenth anniversary of Gagarin's flight. That stamp depicts Vostok in re-entry configuration but fuller details - an illustration of the whole craft - appear in another Soviet miniature sheet celebrating the Twenty-Fifth Anniversary.

The first ever stamp to show the world what Vostok looked like appears to be a Polish one issued in the 1966 series entitled "Space Research" (SG 1709). Thereafter all stamps showing Vostok were able to tell the truth. There is even more legerdemain regarding images of Voskhod on stamps, but that is another story!



Poland SG 1709
(20.12.66)

One-page INTO SPACE articles offer readers the opportunity to express their ideas and 'think aloud' on space topics which they see as important and of interest to others.

Contributions of an appropriate (one-page) length may be sent to the editor at any time and should be accompanied with a photo of the writer (head and shoulders) and a few lines of personal details.



Soviet Union
SG 2578
(12.4.61)

The inference is clear. Gagarin's first flight was not all that secret, if so many stamps were issued within days of his flight. Many designers and postal bureaucrats must have known about it, surely or else how could the stamps have been produced for postal cum propaganda usage so quickly? Imagine then the brief given to the stamp designer. "What does the rocket look like?" "Sorry, comrades we can't tell you - use your imagination!" - and they did!

If you study the first philatelic essays you see a variety of responses to the design problem. The first issues for the Soviet Union - Albania - Bulgaria - Cuba - East Germany - Hungary - Mongolia - and Viet Nam all depict rockets that Jules Verne might have dreamt of and they are all different from each other, some slightly and



East Germany
SG E556
(18.4.61)

WIND Spacecraft

First Russian Instrument on US Satellite

A spectacular pre-dawn launch on 1 November 1994 of a McDonnell Douglas Delta II rocket carried NASA's WIND laboratory into orbit on a mission to study the Sun's influence on the Earth's atmosphere. The three-stage Delta II 7925, launched from Complex 17B of Cape Canaveral Air Station, successfully inserted WIND into a highly elliptical orbit of 422,169 x 162 km extending beyond the Moon on the sunward side of the Earth.

Introduction

The solar wind emanates continuously from the solar atmosphere and consists of electrically-charged particles, mostly positively-charged protons and negatively-charged electrons.

The \$173 million WIND spacecraft will be positioned to measure the basic properties of the solar wind immediately before it collides with the Earth's magnetic field and atmosphere. The complex interplay of forces resulting from this continual collision is responsible for dramatic global effects. One spectacular example, evident high above the Earth's polar regions, is the aurora, or the Northern and Southern lights. Indirect effects of the solar wind may be highly disruptive, manifesting themselves in the form of electrical power system failures, radio communication disruptions and diminished performance and reliability of spacecraft in Earth orbit.

The WIND spacecraft is carrying eight instruments, including one French instrument and the first Russian instrument ever to fly on a United States' satellite. WIND is the first of

BY ROGER G. GUILLEMETTE

Rhode Island, USA

two missions of the Global Geospace Science (GGS) initiative, part of the worldwide collaboration for the International Solar-Terrestrial Physics (ISTP) programme. The aim of the ISTP programme is to understand the physics of the Sun-Earth relationship in order to predict how the Earth's atmosphere will respond to changes in the solar wind.

The second satellite in the GGS series, dubbed POLAR, is scheduled to be launched from Vandenberg AFB, California in November 1995. POLAR will measure the flow of plasma - a solar wind of electrified particles - to and from the Earth's ionosphere. WIND and POLAR will perform simultaneous and closely coordinated measurements of the key regions of Earth's geospace.

POLAR's launch is contingent upon a positive recommendation from a three-member NASA review board that will evaluate WIND's on-orbit performance. This panel will report back to Administrator Goldin who will then make the final determination to proceed with the launch.

Launch on Schedule after Delays

The launch of WIND occurred more than two years behind schedule, the result of six launch delays and a myriad of developmental problems. NASA Administrator Daniel S. Goldin personally delayed WIND's planned April 1994 launch attempt when NASA engineers discovered that the satellite had been built with potentially defective components. The same faulty parts had doomed two other spacecraft, the \$494 million Mars Observer probe and the NOAA-13 weather satellite, that were also built by WIND's prime contractor, Martin Marietta Astro-Space. Over 600 hours of extensive testing of spacecraft systems by Martin Marietta were required to convince Goldin that the spacecraft was ready to be launched.

The November 1994 launch period for WIND opened on the 1st and closed on the 14th; however, only five of those dates were considered to be "stable." If WIND was to be launched on a "non-stable" date, a perigee raise



Lift-off for the WIND spacecraft on 1 November 1994. NASA

manoeuvre would have been required at the first orbit apogee (6 days into the mission) or the spacecraft would have impacted with the Earth on its return trip. Fortunately, the 4:31 am EST launch on 1 November occurred at the optimum moment, eliminating those concerns.

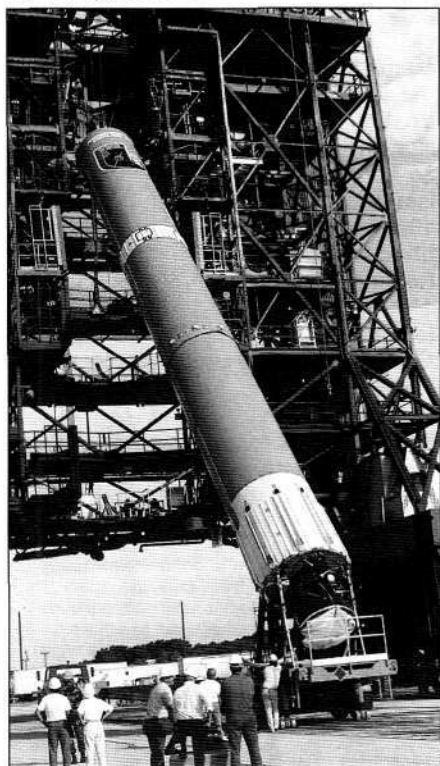
The launch of WIND occurred precisely on schedule (only 57 milliseconds late), placing the spacecraft on a perfect trajectory; the injection orbit obtained from the launch vehicle was one of the most accurate ever flown by the highly reliable Delta vehicle. The orbital insertion was so exact that flight controllers were able to eliminate a trajectory correction that had been scheduled for the second day of the mission. The first perigee phasing manoeuvre, planned for 12 days into the flight, was also deemed unnecessary.

The spacecraft's Medium Gain Antenna, required for a good high-rate communications link with Earth, was deployed on schedule. Subsequent spacecraft reconfigurations and trajectory correction calibration burns have proceeded flawlessly.

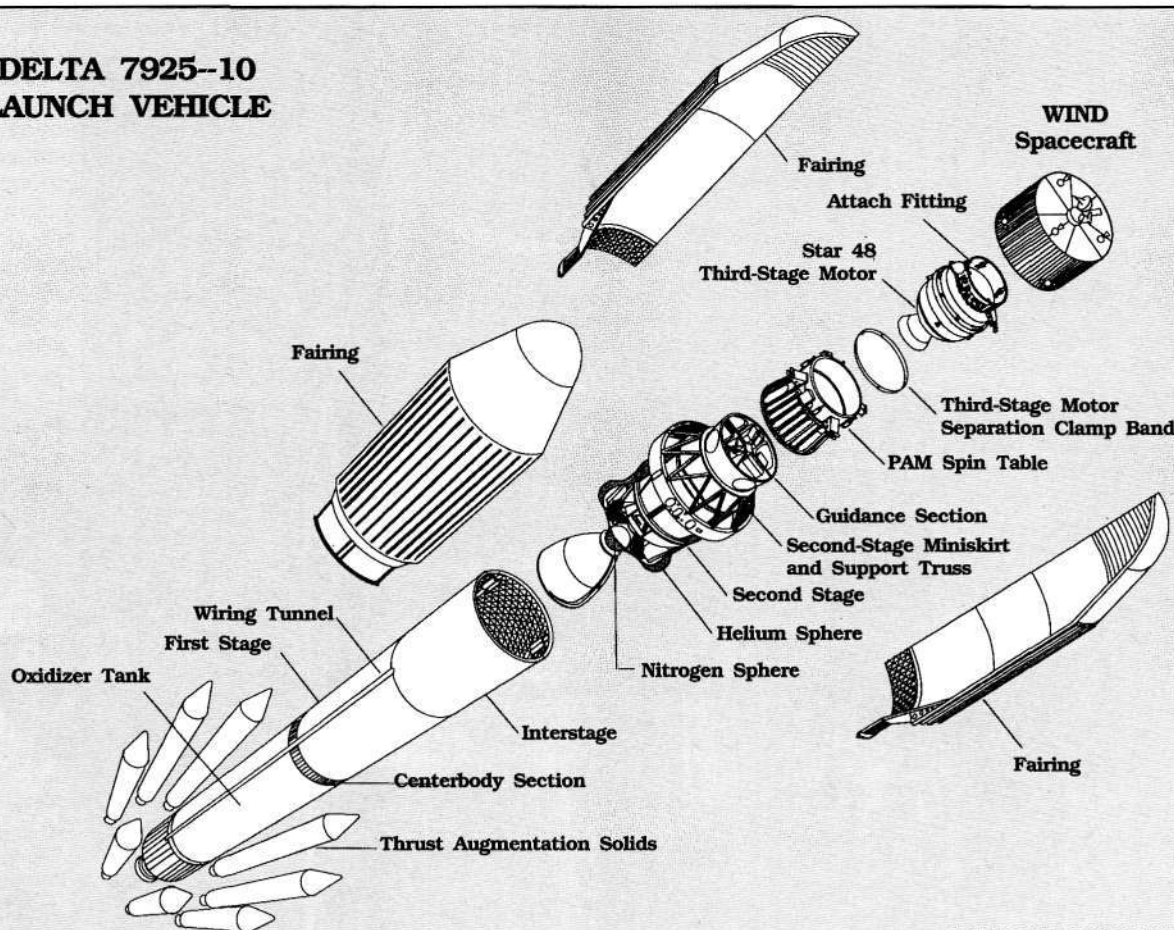
The first 30 days of the mission saw an intense flurry of spacecraft appendage deployments, instrument activations, and thrusting manoeuvres to align the spacecraft properly for its first lunar swing-by on 27 December 1994.

There have been several manoeuvres performed during the first 60 days of the mission to align the spacecraft properly for its first lunar swing-by. Lunar swing-by targeting

The first stage of the Delta 227 launch vehicle is erected at Launch Complex 17, Pad B, at the Cape Canaveral Air Station on 22 August 1994. NASA



DELTA 7925-10 LAUNCH VEHICLE



MDA-SPACE TRANSPORTATION DIVISION

was critical as only a small error would result in the spacecraft escaping the Earth-Moon system. All went as planned and the lunar swing-by and subsequent trajectory trim on 4 January 1995 went without incident. WIND is now in a special seven-month "halo" orbit that will take it well out in front of the Earth's bow shock into the upstream solar wind at the unique distance which allows WIND to always remain between the Earth and the Sun (at about 1,500,000 to 1,690,000 km from the Earth).

WIND/Delta Launch Operations

The three-stage Delta II carrying WIND consisted of five major assemblies: the first stage, including nine strap-on solid rocket motors; the interstage; the second stage; the third or upper stage; and the 3 m diameter payload fairing. The rocket is 38.16 m tall and 2.44 m in diameter and is capable of boosting 1800 kg into a geosynchronous transfer orbit.

The Delta's Rocketdyne RS-27 main engine, operating on a combination of liquid oxygen and RP-1 (kerosene), had a liftoff thrust of 93,895 kg wt. Each of the nine Hercules Aerospace solid strap-on motors had a sea-level thrust of 44,031 kg wt. At liftoff, the combination of the main engine and six of the nine solids, provided a total liftoff thrust of 358,081 kg wt.

Just over a minute into the flight, six of the solid rocket motors burned out at an altitude of about 16 km. Two

and a half seconds later, the three remaining solids ignited on schedule, immediately followed by the jettison of the six burned-out solids.

The discarded solid rockets, glowing like hot embers in a fireplace, were easily visible in the clear November sky as they tumbled in the Atlantic. Ground observers were able to follow the sparkling solids throughout their descent until they finally fell into the ocean.

The first stage main engine cutoff occurred about 260 seconds into flight, followed by the Stage I-II separation. At this point, the rocket passed through the terminator into the sunlight of the approaching dawn, suddenly reappearing from the darkness to the delight of viewers. The Delta second stage engine, an Aerojet AJ10-118K burning Aerozine-50 and nitrogen tetroxide oxidiser, was then ignited at an altitude of 120.5 km.

The Delta's flight path for the WIND launch was on a launch azimuth of 95°, carrying it over Africa into a parking orbit. The third stage, employing a Thiokol Corporation Star-48B solid rocket motor, inserted the WIND spacecraft into a highly elliptical orbit. The time from launch until spacecraft separation was approximately 82 minutes.

The WIND mission was the 24th successful launch of the Delta II 7925, the latest version of the venerable Delta booster, and the 227th launch in a series dating back to May 1960. The

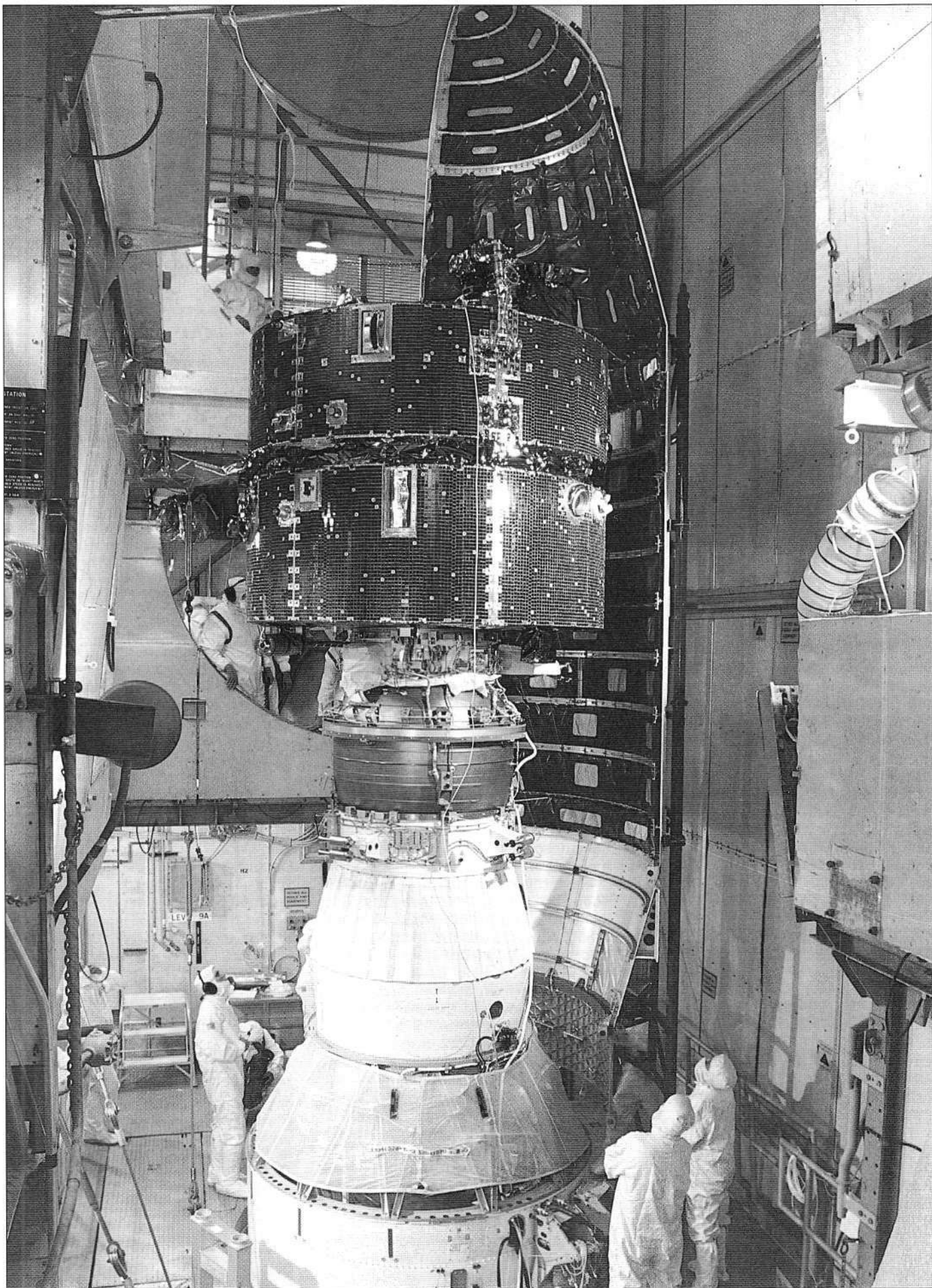
WIND launch was also the 49th consecutive launch success for the McDonnell Douglas Aerospace Delta launch vehicle.

WIND Mission

WIND will study the solar wind; its origin, three-dimensional features and interactions with the Earth for a period of two years. The spacecraft, using the Moon's gravity to conserve manoeuvring fuel, will conduct its studies in orbits both close to and far away from the Earth.

The main scientific goal of the mission is to measure the mass, momentum and energy of the solar wind that is somehow transferred into the space environment around the Earth. WIND's mission may eventually yield long-range benefits such as predicting when dangerous conditions will occur in the solar wind or on the Sun. The predictions could provide just the kind of early warning needed to help minimise damage to susceptible systems. The US Air Force will use WIND data in an effort to develop ways to forecast so-called space weather conditions so that multi-million dollar spacecraft can be safeguarded, such as altering their operations in advance of an approaching solar storm.

As the solar wind approaches the Earth, its momentum compresses the outward extension of the geomagnetic field on the dayside of the Earth and greatly elongates it on the nightside to form the magnetosphere. At a certain



The WIND spacecraft and attached Payload Assist Module-D (PAM-D) booster stage are being encapsulated in a 10-foot-wide payload fairing at Complex 17B at Cape Canaveral Air Station on 25 October 1994. NASA

distance 'upstream' from Earth, the incoming solar wind flow is slowed and deflected by the dayside geomagnetic field, forming a supersonic shock wave located in front of the magnetosphere. WIND will first measure properties of the solar-wind plasma before it reaches the Earth, observing the volume of geospace occupied by the foreshock.

During the early stages of the mission, WIND was ideally situated to measure solar wind particles reflected from the bow shock. At first, the satellite will have a figure-eight orbit around the Earth with the assistance of the Moon's gravitational field. Its furthest point from the Earth will be up to 1,600,000 km and its closest point will be at least 29,000 km.

The launch period for WIND was precisely calculated so that the apogees of the phasing orbit align with the Moon while on the sunward side of Earth. Injection into the lunar swing-by orbit must occur on Earth's sunward side or the spacecraft would head away from the Sun.

WIND Mission Status

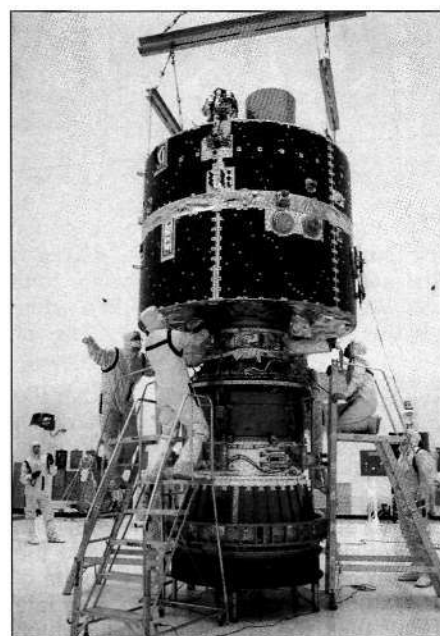
The spacecraft deployables include two 12-meter lanyard deployed canister booms carrying the Magnetic Field Investigation (MFI) instrument and Waves search coils, and two 0.5-meter mini-booms housing the 3D-plasma sensors used for detecting low energy electrons and ions and medium and high energy particles. The MFI instru-

ment is now collecting data on the Earth's magnetic field. All boom deployments and associated spin adjustment manoeuvres that are made to spin up the spacecraft following spin down from the radial wire and lanyard boom deployments went without incident.

Spacecraft performance to date has also been dubbed "phenomenal". NASA Project Scientist, Mario Acuna has dubbed it the "quietest spacecraft ever" with regards to EMI - Electro-magnetic Interference. This compliment reflects very positively upon the efforts of the Martin Marietta Astro-Space Integration & Test team who took elaborate EMI precautions in both degaussing tools and while working on the spacecraft.

The NASA Deep Space Network will collect the data from the spacecraft, while the Goddard Space Flight Center will be responsible for distributing the data to the scientists. The multi-national investigators are electronically connected to each other via the NASA Science Internet, allowing them to coordinate their data-gathering efforts.

The successful launch of WIND, coupled with the launches of SOHO, POLAR and Cluster later this year, will complete the ISTP constellation (in conjunction with Geotail already in orbit). Soon, simultaneous measurements of the effects of the solar wind on the Earth, the spatial region around the Earth, and ultimately, everyone living on Earth, will be possible.

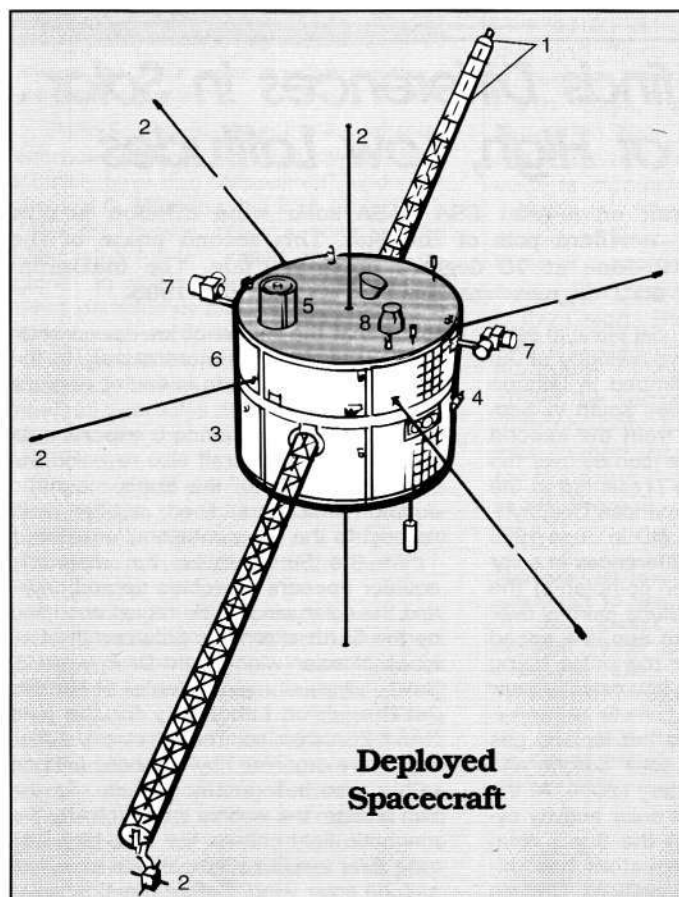


In the Payload Hazardous Servicing Facility the WIND spacecraft is mated to a Payload Assist Module (PAM-D) upper stage booster on 14 October 1994. NASA

Acknowledgements

I wish to thank Ms. Leslie Mathews and Ms. Margaret Persinger of the Press Center at the NASA John F. Kennedy Space Center for their kind assistance, as well as Ms. Terri Bracher of the US Air Force's 45th Space Wing for her continued cooperation. I also wish to acknowledge Mr. Dave Huff of Martin Marietta Astro-Space for his dedication, friendship and invaluable insights.

WIND Spacecraft



The 1254 kg WIND is a cylindrical, spin-stabilised spacecraft, measuring 2.4 m in diameter and 1.8 m high. Dry weight of the spacecraft, excluding instruments, is 895 kg and it is loaded with 300 kg of hydrazine propellant. WIND has been designed for a three-year mission life.

Instruments and Measurements

1. Magnetic Field Investigation: d/c magnetic fields;
2. Radio and Plasma Wave Experiment: a/c electric and magnetic fields;
3. Solar Wind Experiment: mass, energy, direction of low energy ions and electrons;
4. Energetic Particles: Acceleration, Composition, Transport: distribution, mass, energy of ions in 10 keV to 1 MeV;
5. Transient Gamma Ray Spectrometer: high spectral resolution gamma ray detector in 25 keV to 8 MeV;
6. Solar Wind/Mass Suprathermal Ion Composition Studies: mass, energy, detection of ions in 100 keV to 100 MeV;
7. 3D Plasma: distribution and energy of low energy ions and electrons;
8. Konus: high time resolution gamma ray detector.

A pair of lanyard booms, four radial wire antennas and two spin-axis antennas are mounted on the top, bottom and sides of the spacecraft. Curved outer side panels divide the circumference into six segments, each segment divided into upper and lower panels with the region in-between containing sensor apertures. Key elements of spacecraft design were the electrostatic, magnetic and EMI/EMC requirements, while special emphasis was placed on contamination control to insure that the suite of instruments would function as designed.

The WAVES investigation is supported by the Agence Française De L'Espace (CNES), while the Ioffe Institute of Russia is coordinating the KONUS investigation. NASA's Goddard Space Flight Center is managing the WIND programme for the Office of Space Science at NASA Headquarters.

Horizon 2000

Horizon 2000+

The end of 1995 is set to be a period of considerable and intense activity for European space science. Three major projects are coming up for launch. Six satellites, comprising nine tonnes of hardware and sixty experiments, will be placed in orbit with a view to giving scientists a new perspective on the Sun, the Earth's magnetic environment and the universe in general.

In 1985, ESA set up a 20-year (1985-2005) programme designed to pave the way for ambitious science missions. On the basis of the Horizon 2000 programme Europe has launched the Giotto probe, which successfully encountered Comets Halley (1986) and Grigg-Skjellerup (1992); developed the Hipparcos satellite, whose catalogue of 120,000 stars will be published in late 1996; built the Ulysses probe, which has been exploring the third dimension of the Solar System since 1992; and contributed at a rate of 20% to the Hubble Space Telescope programme. It is thanks to Horizon 2000 that Europe is now preparing to launch ISO, Soho and Cluster.

ISO, the Infrared Space Observatory, will allow astronomers to study all types of objects in the Solar System - from nearby planets to the furthestmost galaxies - with unparalleled sensitivity through infrared radiation. Soho, the solar observatory, will be the first satellite to continuously observe the Sun in detail, and will do so for at least two years. The four identical Cluster satellites will probe the Earth's magnetosphere and its variations.

ISO will be launched by an Ariane 44P launcher on a date that has now moved to late October. Soho is scheduled for launch on 31 October by an Atlas rocket. The Cluster quartet will be a payload of the first Ariane-5, whose launch date is currently 17 January 1996.

On the basis of the same long-term plan Europe will build Huygens, the probe to be launched in 1997, in cooperation with the United States, to explore Titan; XMM, the X-ray telescope scheduled for a launch in 1999; Integral, the gamma-ray observatory due to be launched in 2001 in cooperation with Russia; Rosetta, the probe which is to land on Comet Wirtanen in 2012; and FIRST, the submillimetre telescope planned to be in orbit in 2006.

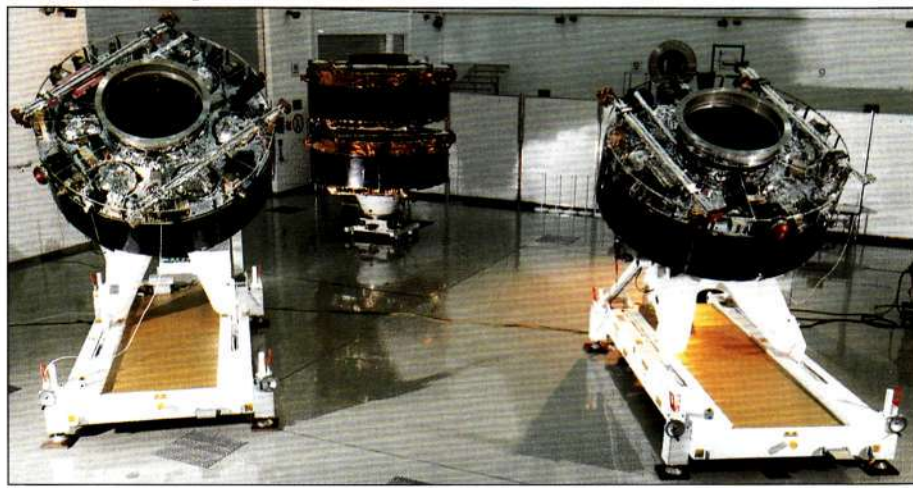
It is now time to look ahead to the next twenty-year period and embark on the follow-up programme for 2006-2016. At the ESA Council meeting to be held in October in Toulouse, European ministers responsible for space will therefore have to take a decision on a "Horizon 2000 PLUS" programme. The proposal being put forward by ESA's directorate of scientific programmes involves setting up three large-scale missions:

- A mission to explore Mercury, the least known of the inner planets, 60% of whose surface has yet to be mapped;

- An interferometry observatory designed to map the sky a hundred times more accurately than the Hipparcos satellite;
- A gravitational observatory able to pick up the space time waves emitted by the universe at the precise moment of the Big Bang.

In parallel, four medium-size missions - their content still to be defined - will be carried out.

The four Cluster spacecraft at IABG, Munich.



Soho will be launched to the L1 Lagrangian point (1.5 million km from Earth) and from there will study physical processes occurring on the Sun for two and possibly for as long as six years.

ESA

ESA

Ulysses finds Differences in Solar Wind at High, Low Latitudes

The Ulysses spacecraft on a joint ESA/NASA solar wind mission is now on its way over the northern pole of the Sun. This second phase of the mission began on 19 June at 70 degrees north latitude. The maximum northern latitude of 80.2 degrees was reached on 31 July 1995.

Ulysses left the equatorial plane in early 1992 after a gravitational swingby of Jupiter, and gradually climbed in latitude until reaching 80 degrees south in September 1994. Results from the second phase of its high-latitude journey over the northern latitudes were presented at the spring meeting of the American Geophysical Union in Baltimore, MD in June 1995 and confirmed global differences in solar wind speed found after completing the first phase of its high-latitude journey over the southern pole of the Sun, the speed of the solar wind over the poles being high compared with its low velocity near the equator.

The solar wind is the hot ionised gas that escapes from the solar corona and expands into interplanetary space. At the present minimum of the solar activity cycle, the angle between the Sun's rotational and magnetic equators has decreased and, in these conditions, Ulysses

found that the region of low-speed solar winds was confined more closely to the rotational equator than in earlier portions of the solar cycle.

Data from science experiments onboard the spacecraft also revealed the strong influence of the Sun's magnetic equator, which is inclined, or tilted, with respect to the sun's rotational equator.

"As the Sun rotates, the magnetic equator appears to wobble up and down and the solar wind in the region occupied by the Earth alternates between the two types of solar wind", said Dr Edward J. Smith, Ulysses project scientist at NASA's Jet Propulsion Laboratory for the joint NASA-ESA mission. These velocity differences are organised by magnetic latitude rather than heliographic latitude. As the Sun rotates, the wobble introduced by the magnetic field causes the fast, high latitude solar wind to alternate with slow, low altitude solar wind. Before the slow solar

Neglected Mercury!

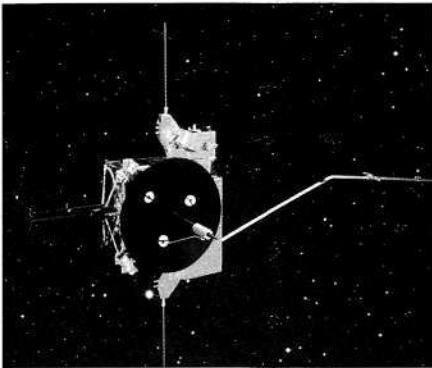
BY PATRICK MOORE

BIS Fellow

wind has time to reach the orbit of Earth, it is overtaken by the faster wind, forming a high pressure "front", which is somewhat equivalent of a weather front on Earth and is responsible for much of the interplanetary 'weather' which causes aurora. These fronts also cause magnetic storms, which can interrupt radio and satellite communications on Earth".

Scientists at the American Geophysical Union meeting, describing the return of Ulysses to the equatorial zone, reported a drop in the solar wind speed by a factor of two - from approximately 800 km/s over the southern pole to approximately 400 km/s along the equator - and the reappearance after two years of large excursions in speed, particle density and magnetic field strength.

"Magnetic fields characteristic of the north solar hemisphere, which point outward from the Sun, are seen interspersed with inward-directed fields from the southern hemisphere," Smith said. "This change in the magnetic field polarity indicates whether the solar wind is coming from the south or from the north. Thus, the equatorial zone in which the Earth is located is alternately traversed by particles originating from northern or southern regions of the Sun".



Ulysses the solar probe overflies the Sun's poles and equator. ESA

"Periodic excursions in the flux of solar energetic particles between low and high intensity have also reappeared", added Dr Richard G. Marsden, the ESA project scientist for Ulysses. "They accompany the solar wind fronts - called interaction regions - in which energy is transferred to these particles by shocks associated with the interaction regions".

An unexpected feature of the Ulysses observations was the detection of these energetic particles at higher latitude than the shocks that are known to create them.

The scientists pointed out that high particle speeds over the poles and low speeds near the equator are very likely tied to the current phase of the Sun's 11-year sunspot cycle.

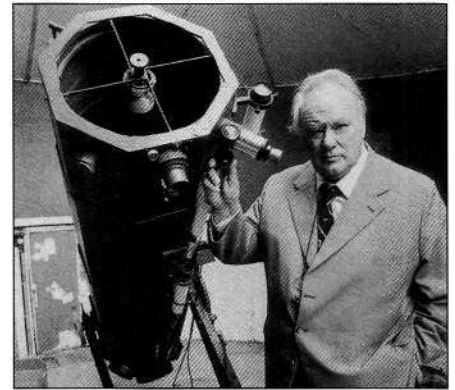
Currently the Sun is very near to its minimum of activity, with just a few spots observed at low latitudes. In particular the equatorial zone has been found to be only half as wide during the passage taking place from September 1994 to March 1995 compared with the earlier equator-to-pole passage. The shrinking of the equatorial zone in the intervening two years shows the close correspondence between the Sun's rotational and magnetic equators.

We hear a great deal about the familiar planets, Venus and Mars, and by now talk of a Martian Base is certainly not far-fetched. We hear much less about Mercury, and this is understandable enough; it is never prominent, it is not a great deal larger than the Moon, and it is totally unsuited to our form of life. Only one spacecraft - Mariner 10 - has passed by it, and this was twenty years ago now.

Things were different once - so we thought. In 1934 E.M. Antoniadi, the best planetary observer of the time could write that on Mercury "A more-than-glacial breeze would be extremely punishing during the night, while a wind incomparably more scorching than the desert simoom would probably give rise to a spectacle of fuming dunes, which during the day would raise eddies of greyish dust which would cover the sky and conceal even the Sun with sinister, all-obscuring clouds... If volcanic eruptions occur, they might help in producing beautiful rosy twilight effects". Antoniadi also believed that Mercury's rotation period was equal to its sidereal period (88 Earth-days), in which case there would be an area of permanent day, an area of permanent night, and only a narrow 'twilight zone' in between over which the Sun would rise and set.

All this is wrong, as we now know. The Mercurian atmosphere is negligible, and there can be no clouds or vulcanism. The rotation period is 58½ Earth days, or two-thirds of a Mercurian year, and the temperatures are extreme. But as yet our knowledge is incomplete.

Mariner 10 made three active passes of Mercury, and sent back pictures of a crater-scarred, mountainous landscape; the most imposing feature is the Caloris Basin, 1300 km in diameter and bounded by a ring of smooth mountain blocks rising 1 to 2 km above the surrounding surface. Unfortunately only half the Caloris Basin was imaged. At each Mariner encounter the same regions were in view. All in all, there is still more than half of



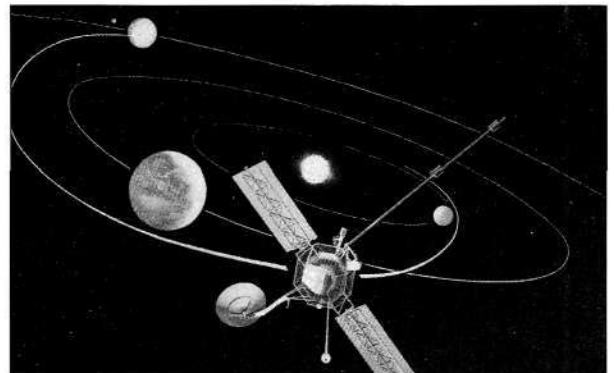
Mercury about which we have no direct information.

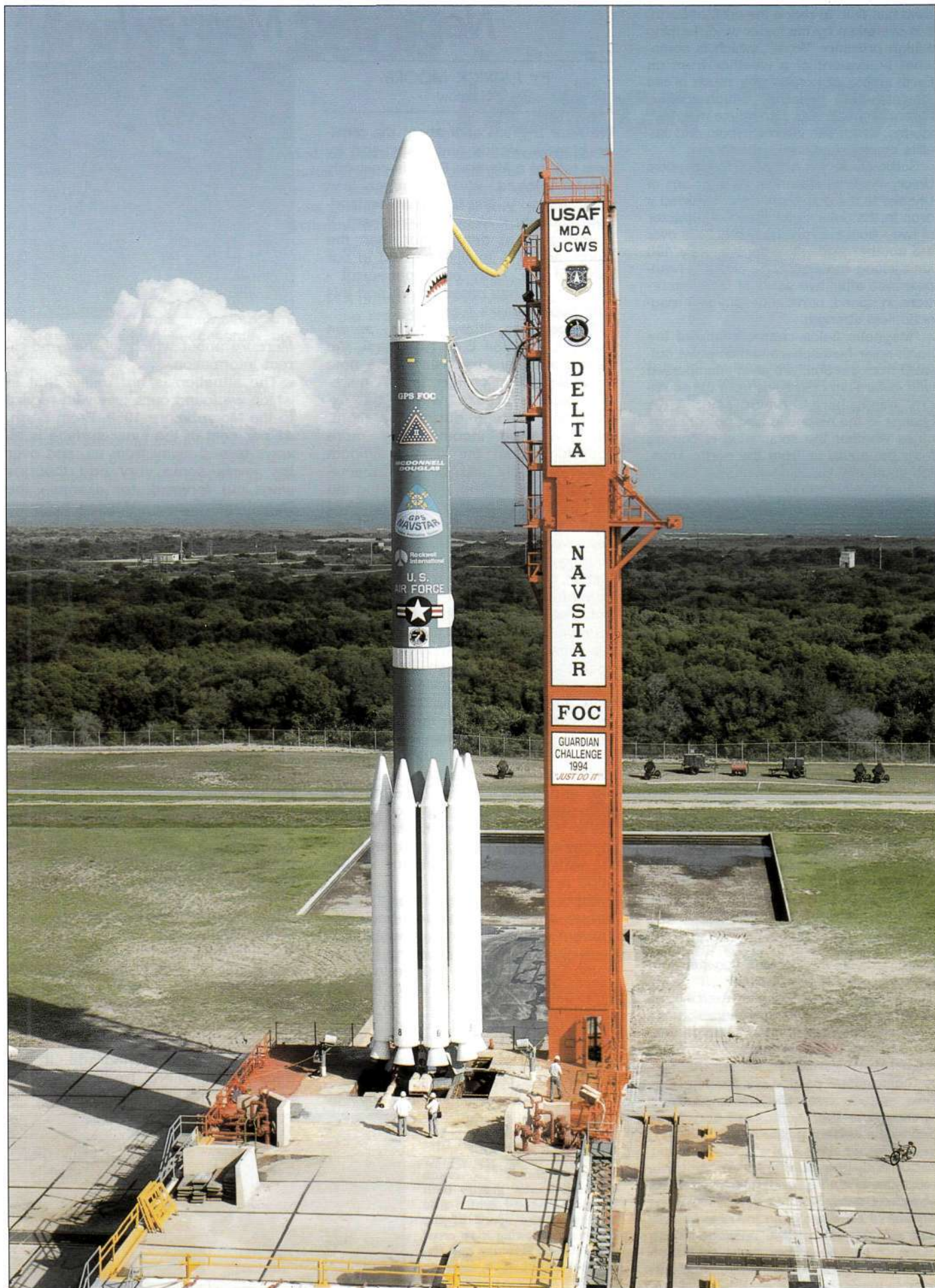
The situation is not unlike that in which we found ourselves with regard to the Moon before 1959. From Earth, 41 per cent of the lunar surface is always turned away from us, and over the years some very odd theories were put forward; for example the Danish astronomer Hansen believed the Moon's centre of mass to be displaced, so that all the air and water would have been pulled round to the far side - which might well be inhabited. In 1959 Lunik 3 went on a 'round trip' and told us that the far side was just as barren and just as cratered as the side we have always known, which came as no surprise at all.

Will the same be true of the unmapped regions of Mercury? In my view, yes. There is absolutely no reason to believe that the remaining areas are basically different from those surveyed by Mariner 10, but it would be good to know definitely, and in July a meeting in London was called to discuss a further Mercury probe. If all goes well, it will be launched within the next few years. Certainly we must hope so; hostile though it may be, Mercury is a fascinating little world, and it has been very much neglected in the recent past.

Incidentally, why is the Caloris Basin so called? Because when Mercury is at perihelion, the Sun is overhead there; and Caloris means 'heat'. The Basin is the hottest part of Mercury, and the temperature can rise to a torrid 427 degrees Centigrade. If you decide to go there, I advise packing some very effective sun lotion. ■

Mariner 10 was the first spacecraft to use the gravity of one planet to reach another. Venus' gravity both deflected the orbit and decreased the speed of the spacecraft allowing it to cross the orbit of Mercury and fly-by the planet at a distance of 1000 km. NASA





A McDonnell Douglas Delta II launch vehicle stands ready on Complex 17A at Cape Canaveral Air Station to carry the 24th Navstar Global Positioning System (GPS) satellite into orbit on 10 March 1994 to complete the Navstar/GPS operational constellation. USAF

Building Rockets

BY JOEL W. POWELL
Space Information Canada

(All photos supplied by the author
unless otherwise stated)

A visit to the Delta II Assembly Plant, Huntington Beach

Think of the phrase 'rocket factory' and images of spotless clean-rooms filled with white-gowned technicians may spring to mind. To learn more about the actual process of building rockets, the author arranged to visit the factory where the McDonnell Douglas Delta II is built, located in the Los Angeles suburb of Huntington Beach, California.

Introduction

The Delta assembly plant on Bolsa Avenue was established in 1963 to produce S-IVB upper stages for the Saturn V Moon rocket. S-IVB production continued there until the Apollo programme was cut back after the first few lunar landings. The historic Skylab space laboratory (a converted S-IVB stage) was also assembled at Huntington Beach.

Delta rockets were originally manufactured at the Douglas Aircraft plant in Santa Monica, California. Production was transferred in 1972 to the McDonnell Douglas factory at Huntington Beach (Douglas merged with rival McDonnell Aircraft in 1967) to keep open the more modern facility on Bolsa Avenue. While continuing to fabricate Delta components at Huntington Beach, McDonnell Douglas decided to relocate final assembly work to Colorado in 1987 as a cost-cutting measure (see "Pueblo Assembly Facility", below).

Delta II

Today's Delta launch vehicle is descended from the Thor-Able booster developed by the Air Force in the late 1950's, utilising a Thor intermediate range missile as the first stage. Thor production commenced at Santa Monica in October 1956, followed by the initial batch of Deltas for NASA in late 1959. To date there have been 227 Delta launches, including 41 from Vandenberg Air Force Base in California. Only twelve attempts have ended



The author and a Delta interstage section inside Building 45 at Huntington Beach.

in failure since the first flight in May 1960, an enviable 94.7% rate of efficiency.

Delta production was actually terminated in 1984 as NASA attempted to make a transition from expendable vehicles to the Space Shuttle for satellite launches. As a result of the Challenger accident, production was restarted on an emergency basis in 1986 and was completely resurrected a year later when McDonnell Douglas won an Air Force contract to launch two dozen Global Positioning System (GPS) satellites eliminated from the shuttle manifest.

An upgraded version of the launch vehicle, the "interim Delta II" (model

6925) was created for the navigation satellites by extending the first stage propellant tanks by 3.7 m and adding new graphite-epoxy solid rocket motors. Addition of a more powerful main engine in 1989 resulted in the current model 7925 of Delta II.

Delta Production Line

Somewhat surprisingly, the Bolsa Avenue assembly area is just an ordinary-looking industrial plant - no airlock entrances or clean-rooms here. Several doors in Building 45, the assembly area, were actually open to the outside air. None of the workers wore anything more elaborate than a regular blue or white smock.

With a production capacity of 12 vehicles per year, fabrication of each Delta takes about six months. The process begins with the preparation of the 4.7 m aluminium sheets that will eventually comprise the rocket's structure. Two massive Cincinnati "Milacron" milling machines, centrally located on the Building 45 shop floor, are employed to mill a triangular iso-grid pattern in the aluminium. More than half of the metal in each sheet is eventually removed in the process of milling the iso-grid pattern, which preserves structural strength while saving weight.

The finished panels are hydraulically curved on site in special jigs to form the barrel sections of each fuselage.

Cincinnati 'Milacron' milling machine at work in Building 45 on a payload fairing panel.



Three curved aluminium panels are welded together to produce the cylindrical fuselage sections - one each for the first stage fuel and oxidiser tanks (later joined together in Colorado - see below) and one for the interstage section (see photo on preceding page). These cylinders look for all the world like big oil pipeline segments, although a partially completed payload fairing visible from the main aisle definitely looked like it belonged to a rocket.

Bulkheads for the first stage propellant tanks are stamped out of circular sheets of aluminium at a local metal-working shop and delivered to Building 45 for finishing and installation. According to one of the Delta engineers conducting the tour, McDonnell Douglas utilises an ingenious interference fit process to secure the bulkheads. Each end piece, which is several thousandths of an inch wider than the interior diameter of the propellant tank, is chilled cryogenically to shrink it at the same time as the tank skin is heated to make it expand. The dome is then slipped into place, wedging permanently into position as temperatures return to normal. When engineers recently discovered micro-fatigue cracks in the vicinity of the bulkhead access ports, a new bolted flange was installed to reinforce the problem area.

Upper Stages

The smaller-diameter second stages are assembled in a facility adjacent to Building 45 (not part of the tour). Stage two measures 1.7 m in diameter and features conventional alu-



McDonnell Douglas' Balsa Avenue plant in Huntington Beach where Delta II is manufactured.

minium construction. In order to maintain a constant 2.4 m diameter for the entire vehicle, the second stage is enclosed within a 4.7 m interstage unit, supported by a mini-skirt attachment fixture. The payload fairing (which also covers the top part of the second stage) sits atop the mini-skirt ring.

Staging takes place approximately eleven minutes after launch. Eight seconds after stage one shutdown, explosive bolts fire and six spring-actuated rods eject stage two from within the interstage. The 5.9 m upper stage (with nozzle) ignites five seconds after separation and burns for nearly five minutes. Payload fairing jettison occurs shortly after second stage ignition. The third stage Payload Assist Module (PAM) is ignited about 75 minutes after liftoff to inject the payload into the proper transfer orbit trajectory.

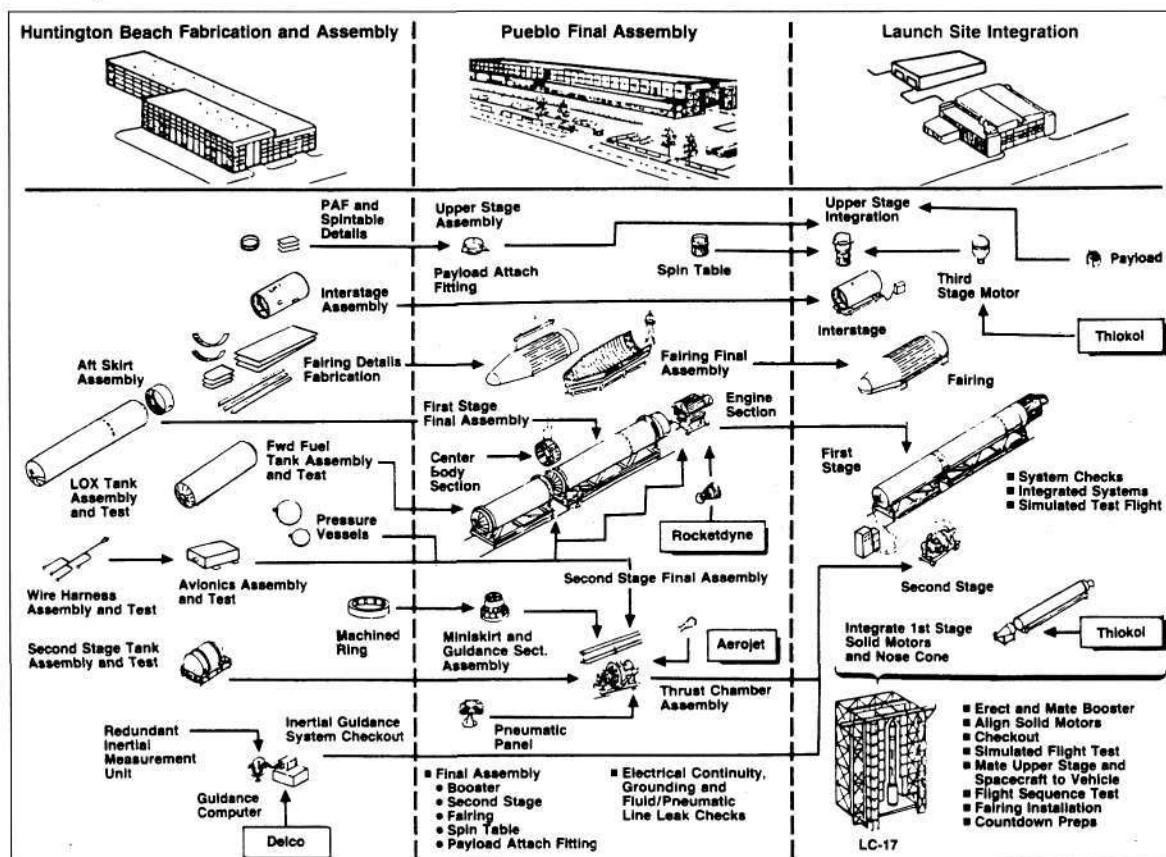
The spin tables and support structure of the PAM stages are also manufactured at Huntington Beach. Payload Assist Modules, incorporating Star 48B solid propellant motors provided by Thiokol, were first introduced on Delta in 1982. High and medium altitude payloads - communication and navigation satellites - require PAM stages on Delta II (model 7925), while Low Earth Orbit missions (model 7920) do not.

Payload Firings

Aluminium sheets for payload fairings are milled along with fuselage panels in Building 45. The fairings come in two different sizes (3.05 m and 2.4 m in diameter) to accommodate wide and narrow body payloads. McDonnell Douglas is the leading producer of fairings in the United States, having built more than 350 since the Pioneer lunar probes in 1958. The company has supplied all of these en-

Delta II production flow.

MDSS





Left: A McDonnell Douglas technician works on the Delta first-stage propellant tank prior to installation of bulkheads. Note the isogrid pattern inside.

Below: A section of a Delta payload fairing stands with two first-stage skirts in the foreground. On the right are unfinished propellant tanks.

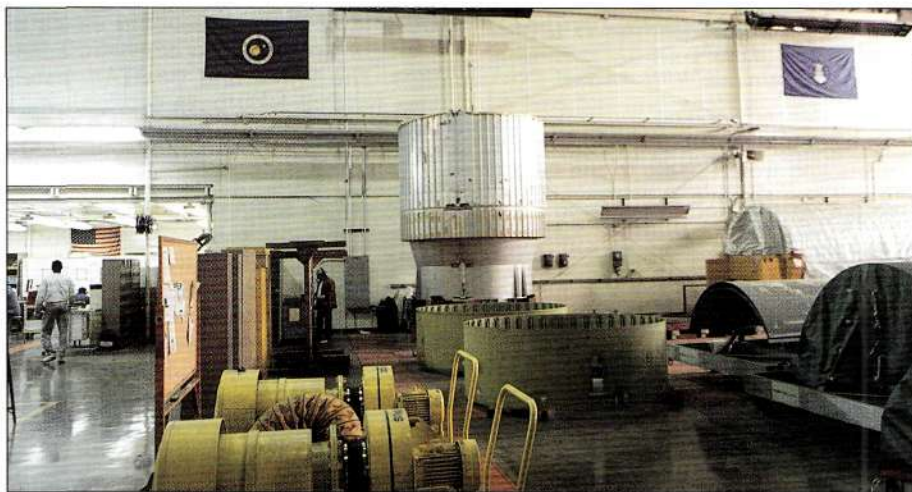
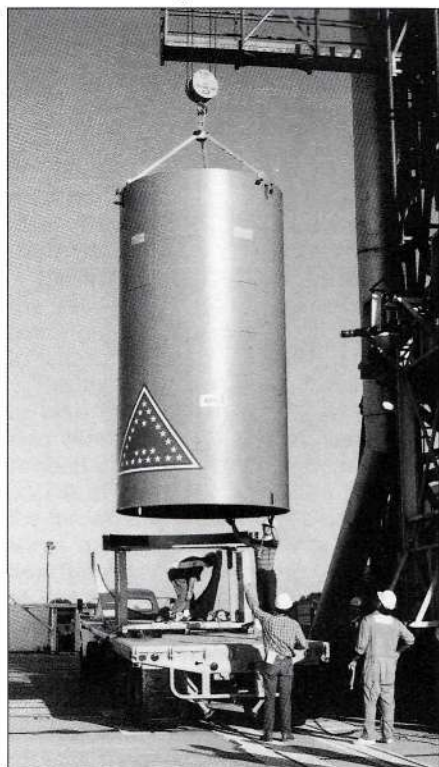
closures for Delta since 1960, and currently produces the fairings for Lockheed Martin's Titan family of launch vehicles.

The 8.5 m Delta fairings incorporate a unique contamination-free jettison system, according to a resident McDonnell Douglas engineer. A flexible tube, much like a bicycle inner tube, lines the edges between the two fairing halves (three segments for Titan IV shrouds) to contain the expanding gases from the charge that triggers separation. The tube expands in the groove as it fills with gas, literally "popping the rivets" and pushing the segments apart without any explosive debris or noxious gases to affect delicate payloads.

Pueblo Assembly Facility

After receiving the contract to produce Delta II, McDonnell Douglas elected in April 1987 to transfer final assembly operations from Huntington Beach to a former steel mill site at Pueblo, Colorado. A favourable lease

The Delta 179 interstage section at the launch site in September 1986. NASA



agreement and lower labour costs prompted the move to the 5,574 m² Pueblo Assembly Facility, where wiring harnesses and engines of both stages are installed. First stage fuel and oxidiser tanks are also joined together at Pueblo. The first vehicle completed at the facility was Delta 181, a standard model rolled out on 2 September 1987 which was launched five months later for the Strategic Defense Initiative Office (SDIO).

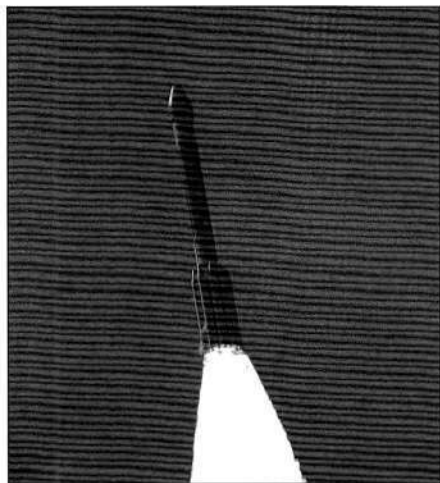
First and second stage tankage (plus payload fairing components) are transported by road from Huntington

Beach to Colorado for final assembly. Up-rated RS-27A main engines with 12:1 expansion ratio nozzles (introduced specially for Delta II) are incorporated in each first stage. The basic RS-27 for Delta was adapted by Rocketdyne from the Saturn I H-1 power plant and flew for the first time in 1975. An improved Aerojet AJ-118K motor originally developed for Martin Marietta's Transtage (Titan III) was adopted for the Delta second stage in 1982. Prior to that time, Delta's second stage was powered by TR-201 engines derived from the TRW Lunar

Delta II propellant tank sections at the Pueblo Assembly Facility in Colorado.

MCDONNELL DOUGLAS





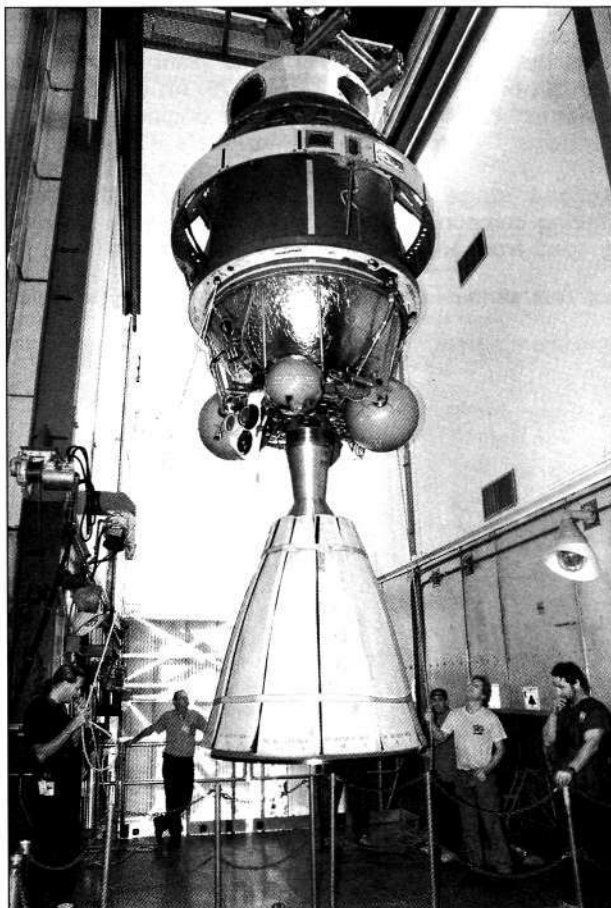
Delta 221 soars aloft from Pad 17 in June 1993 in this photo taken by the author using a 500 mm lens with doubler.

Module descent engine.

The completed stages and fairings are trucked from Pueblo to the launch site at Cape Canaveral or Vandenberg Air Force Base. After pre-launch checkout, the 34.8 m rocket (with fairing) is transported to the launch pad for erection and mating of the nine Hercules graphite-epoxy solid motors (GEM's). Space Launch Complex 2 West (SLC-2W) at Vandenberg has recently been converted to Delta II specifications (there has not been a Delta launch at Vandenberg since 1989), with the first launch scheduled in mid-1995 to carry the Pentagon's Midcourse Space Experiment (MSX) payload.

Technicians prepare to lift the second stage into position at Launch Complex 17 for Delta 227 in August 1994 in preparation for the launch of the WIND spacecraft.

NASA/KSC



Delta II Outlook

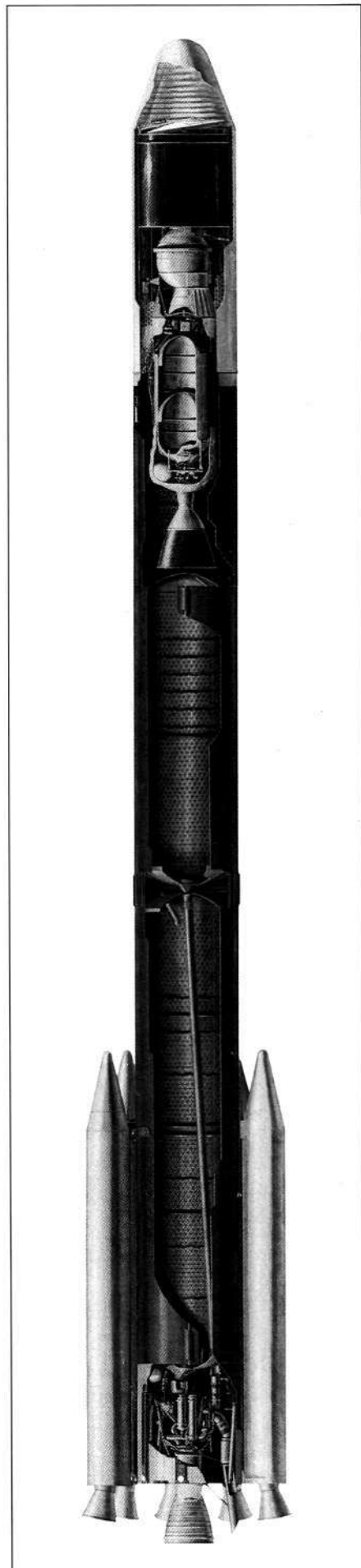
Delta II is guaranteed ample utilisation well into the 21st Century. In April 1993 the Air Force awarded McDonnell Douglas the MLV-III (Medium Launch Vehicle) contract to supply up to 36 Delta II's for military payloads (the first of which is MSX) to the year 2002. Beginning in 1996 a total of forty IIRIDIUM communications satellites for Motorola will be launched five-at-a-time on eight separate Delta II boosters. McDonnell Douglas also has three additional commercial contracts extending from 1995 to 1997.

NASA's new Medium Expendable Launch Vehicle Services contract (MELVS) calls for up to 15 additional Delta II vehicles to launch a series of planetary probes and scientific satellites. The WIND and GEOTAIL satellites have already been orbited, while POLAR, RADARSAT and the X-Ray Timing Explorer (XTE) are due for launch in 1995.

Upcoming MELVS launches include Mars Pathfinder and Mars Surveyor in 1996 plus the first low-cost Discovery probe, NEAR (Near Earth Asteroid Rendezvous). With a "Delta 3" development now underway, Huntington Beach and the Pueblo Assembly Facility may be building rockets for many years to come.

Acknowledgement

Many thanks to Evelyn Smith and the staff of McDonnell Douglas Aerospace Public Affairs in Huntington Beach for arranging this unique tour of the Delta assembly plant.



A cutaway of the earlier Delta model 3920 reveals the iso-grid structure of the first-stage propellant tanks and positions of the second and third stages.

MCDONNELL DOUGLAS

Three EVAs for Mir Duo

Whilst the Mir-19 crew of Anatoloi Solovyov and Nikolai Budarin was scheduled to have one of the shortest visits to the Mir station - about 70 days - there was to be no shortage of activity for the duo, with most of the important activity crammed into the second half of July.

Mission planners had scheduled at least two EVAs for the two cosmonauts and they were to oversee the arrival and unloading of an unmanned cargo ship.

The first EVA was a vital one and was scheduled for 14 July, just 10 days after the departure of the STS-71 Atlantis crew.

Eight Busy Days

The period 14-22 July was one of the busiest of the entire Mir programme and began with the first EVA on 14 July. The planned duration was 5 hours 14 minutes, and it began at 0344 GMT when Solovyov and Budarin opened the hatch of the Kvant-2 module, which they exited at 0352. Their tasks included:

- Inspection of the face of the -Z docking port, where the Kristall module was to be relocated;
- Inspection of one of the two solar arrays on the Kvant-2 module which was not tracking the Sun correctly;
- Repair of the jammed solar panel on the Spektr module.

Using the telescopic jib mounted on the base block the men moved to the front of the Spektr module and proceeded to work on the stuck solar panel.

At the end of the work the Spektr array was only partially unfurled. There was still one section stuck but the men's work enabled them to route the power output into the electrical system of the complex.

The cosmonauts concluded the EVA after staying outside 5 hours and 34 minutes.

Kristall Redocked

On 17 July the cosmonauts supervised the redocking of the Kristall module to the -Z port freeing the -X axial port for the arrival of Progress M-28. The operation, beginning around 0230 GMT took about 90 minutes.

The next day the Russians said that the second planned EVA was to take place on 19 July and was scheduled to last for 5 hours and 38 minutes.

The main task of this excursion was to take the large Belgian-French-Russian Miras infrared spectrometer (described in *Spaceflight* August 1995, p.273) and assemble it on a boom at the far end of the Spektr module. The Miras has a mass of 220 kg. In addition the cosmonauts were to retrieve at last the American Trek cosmic ray detector that had been placed on the exterior of the Kvant-2 module in 1991. Originally scheduled to be brought back to Earth during 1993 the EVA planners had consistently failed to make a place in the subsequent EVAs

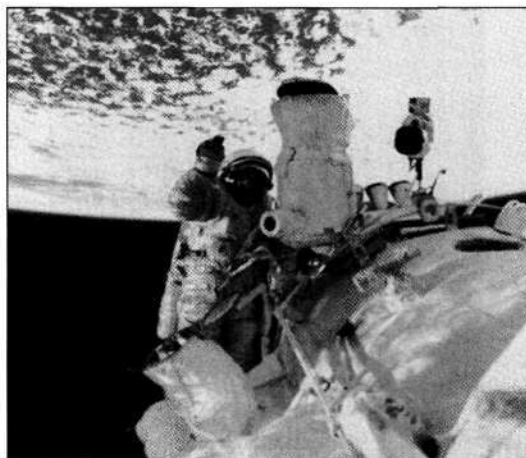
for the 20 minutes required for the retrieval.

One source said the Miras EVA was originally scheduled for 18 August but had been moved forward.

EVA Difficulties on 19 July

EVA-2 began at 0039 19 July. However, within minutes it was noted that Solovyov's Orlan-D EVA suit had suffered from a malfunction in the cooling system. The commander had to remain attached to the hatch of the Kvant-2 whilst Budarin brought back the Trek detector and the cassettes with construction materials which had been exposed to space and put new ones outside to replace them.

The Miras deployment was post-



Quiz picture: An unidentified Mir EVA, but which one and when? If you think you know, *Spaceflight* would like to hear. No prizes offered.

poned until engineers and planners had studied the problems experienced with the suit.

Finally, during the EVA close-out of the hatch of the Kvant-2 module, Solovyov and Budarin were dismayed to find that the hatch would not hermetically reseal. The resultant gap was 2 mm and allowed air to escape. In addition an EVA suit umbilical cord was left dangling outside the airlock.

Initial reports did not specify how this problem was to be fixed but the EVA duration was officially given as 3 hours and 8 minutes.

Progress M-28 in Orbit

The problems in space did not affect the next step in this busiest of weeks - the planned launch on 20 July of the unmanned cargo ship Progress M-28.

BY NEVILLE KIDGER, FBIS

Leeds, UK

The Soyuz-U booster with the craft atop it was launched from Launch Complex Number 1 (Gagarin's) of the Baikonur Cosmodrome at 0304:40 that day. The launch was conducted by the Russian Military Space Forces and specialists of the Russian Space Agency under the supervision of Col-Gen Vladimir Ivanov.

The cargo ship carried 2.4 tonnes of cargo from an initial launch mass of 7.125 tonnes. Of the cargo, some 900 kg was fuel and oxidiser, 400 kg was science equipment and 706 kg was water, food and documentation.

The craft carried almost 350 kg of equipment due to be used by the next long-stay crew of the complex, the EO-20/EuroMir-95 crew who were due for launch on 1 September for a stay of 135 days (see p.314).

Progress M-28 was placed into an initial orbit of 191 x 259 km with an inclination of 51.6 degrees. According to Russian data provided on the Internet the cargo ship conducted a two-impulse burn to start manoeuvring to the Mir station at 0647 and 0737 on the morning of launch.

EVA-3 on 21 July

EVA-3 began at 0030 on 21 July with a planned duration of 5 hours and 34 minutes.

The two cosmonauts dragged the umbilical cord left outside two days earlier back into the station and carried out the Miras spectrometer.

The men again used the telescopic jib to reach Spektr with the instrument and installed the device as planned.

It was reported that the TsUP was able to only hear the cosmonauts during the EVA via relays from the Altair geostationary satellite and no video was provided.

The cosmonauts closed out their final planned EVA of the mission after 5 hours and 35 minutes.

Progress Docks

Progress M-28 was commanded to an automated docking with the -X front axial port of the Mir base block at 0440 on 22 July. The approach was reportedly not televised and the cosmonauts monitored the approach through the portholes of the complex.

The cosmonauts opened the hatch just after 0700 to begin unloading the cargoes.

Acknowledgement

Some of the data in this report was provided by Johnathan McDowell and Chris Van Den Berg. ■

Psychology

Problems Arise as the Months Drag On

AND

Physiology

"Human Lab Rats" for G-Effect Studies

Russian cosmonauts Vladimir Dezhurov, Gennadi Strekalov and US physician astronaut Norman Thagard, the crew members of the Mir-18 mission, had conducted a pre-planned exercise and science programme throughout their time on the Mir station. With the arrival of STS-71 detailed tests could be conducted on Atlantis which would allow a thorough end to their schedule.

Introduction

The Spacelab module, in the cargo bay of Atlantis, was equipped to be a fully functional examination room for the medical team of the STS-71 mission - astronaut physicians Bonnie Dunbar and Ellen Baker.

The medical experiments that could now be conducted, once command of the Mir station had been handed over officially to cosmonauts Solovyov and Budarin, represented the first chance that NASA scientists had ever had in 21 years to study the effects of exposure to long-term weightlessness on human participants.

The official objectives of the Spacelab-Mir science programme also included an evaluation of the methods used by the Russians on their long missions to counteract the effects of long durations in space on the human body.

General Description

The general science objectives were to obtain engineering and operational experience of working in a space station, developing a profile of the Mir environment as it related to microgravity research and the life sciences, to help understand post-flight and future investigations, and to conduct specific experiments in several scientific disciplines.

The investigations involved 29 separate science experiments in seven research areas as shown in the table below.

Discipline	No. of individual experiments
Regulatory physiology	10
Cardiovascular studies	6
Neuroscience	4
Hygiene, sanitation and radiation	4
Behaviour and performance	1
Fundamental biology	2
Microgravity	2

The first five disciplines involved medical examinations and analysis of the crewmembers whilst the latter two involved studies of how weightlessness affected plants and animals in the greenhouse and incubator experiments and studies of the effects of movement

and thruster firings on the microgravity environment of the Mir complex with the addition of a protein crystal growth experiment delivered by STS-71.

The period of the Mir-18 crew's flight on Atlantis was used to collect data and samples from them, compare US and Russian hardware and protocols within the same investigation and obtain post-flight life sciences data from long-duration crew members.



Left to right: US physician astronaut Norman Thagard and Russian cosmonauts Vladimir Dezhurov and Gennadi Strekalov on board Mir. NASA

"Lab Rats"

The Mir-18 crew described themselves as "human lab rats" because of the depth and detail of the medical examinations. The NASA physicians wished to gather data about the three men whilst the flight was still underway so that any subtle and rapid changes which the human body undergoes when adapting back to Earth gravity would not affect their samples and studies.

During their stay on the Mir complex the three men had donated large amounts of saliva, blood and urine as part of the medical experiments. The bodily fluids, collected at various stages of the 115 day flight, were often "tagged" with a tracer chemical to allow analysis of the effects being encountered.

The gathering of these bodily samples continued during the Atlantis Spacelab portions of the flight. The samples gathered during the Mir-18 flight were



The STS-71 crew patch design depicts the Orbiter Atlantis in the process of the first international docking mission of the Space Shuttle with the Russian Space Station Mir. The names of the 10 astronauts and cosmonauts who will fly aboard the Orbiter are shown along the outer border of the patch. The rising sun symbolises the dawn of a new era of cooperation between the two countries. The vehicles Atlantis and Mir are shown in separate circles converging at the centre of the emblem symbolising the merger of the space programmes of the two spacefaring nations. The flags of the United States and Russia emphasise the equal partnership of the mission. The joint programme symbol at the lower centre of the patch acknowledges the extensive contributions made by the mission Control Centres of both countries.

The crew emblem was designed by aviation and space artist, Bob McCall, who also designed the crew patch for the Apollo-Soyuz project in 1975, the first international space docking mission.

BY NEVILLE KIDGER, FBIS
Leeds, UK

transferred to Atlantis by the crew.

On Mir, the samples were stored in the ESA freezer and eventually transferred to the large US freezer located on the Spektr module following the docking of that module on 1 June.

One of the findings of Thagard during the mission was the need for crew members to correctly document the location of equipment and samples and also be provided with sufficient room on the station for storage.

Orthostatic Intolerance

One of the main study areas of concern to NASA scientists was that of how the body readapted to the one gravity environment on return to Earth and the time taken to readapt.

The Spacelab-Mir science team noted that so-called post-flight orthostatic intolerance was a major concern in studies of cardiovascular adaptation to weightlessness. The condition is a function of the cardiovascular system's inability to provide adequate blood flow to the brain whilst standing and, according to the team, has affected 60% of crew members returning from space. The normal posture for shuttle crews returning from orbit is one of being seated upright.

There was concern that the Mir-18 crew would suffer badly from orthostatic intolerance and the three returned to Earth in a recumbent position.

The studies in Spacelab had used an ergometer. The crewmembers' cardiovascular deconditioning was measured as they peddled the stationary

bicycle to 85% of their pre-flight performance, or were too tired to continue, measuring their capacity through aerobic channels (using oxygen). This method gives an indication of exercise capacity and thus the efficiency of the exercise.

The neuromuscular and sensory-motor portions of the disciplines involved the study of the skeletal and muscular performance during an extended spaceflight to study the degree of atrophying experienced, the head/eye coordination of the subject and a study of posture and locomotion involving inflatable shoes and walking exercises on the treadmill.

"Testy" Cosmonauts

However, the science programme was far from easily conducted as evidenced by the comments and behaviour of the Mir-18 crew who were described as "testy". Thagard complained at one stage that the treadmill tests were too hard for a crew completing an almost four-month long mission.

Thagard refused to wear the holter monitor more than once because of the discomfort of shaving his chest repeatedly for the electrodes to be stuck on.

Mir-18 commander Dezhurov actually refused to wear the NASA LBNP and even complained to the Kaliningrad TsUP about the experiments, whilst Strekalov balked at certain procedures involved in the experiment.

NASA's science team replanned their schedule constantly to accommodate the changes. There was much discussion about the attitude of the three men during these tests and a NASA spokesperson even ventured that the men were volunteers and could pull out of the tests if they wished. It was noted, however, that Thagard, despite his protestations, had followed the protocols of the scientific experiments.

Psychological Problems

Even with the problems of the medical experiments, the main story at the end of the STS-71/Mir mission seized upon by the press involved comments made during press conferences by Thagard. The doctor made several comments regarding his mental state which were widely reported as criticisms of the Mir station.

Indeed, one Russian writer labelled the doctor a "whiner" for his comments. Reporters even questioned STS-71 commander Robert "Hoot" Gibson about Thagard's seeming "testiness".

Such comments hardly seem fair considering that Thagard was doing what he had been sent to the Russian space station to do - experience life on the orbital outpost and report his findings so that the other four NASA astronauts following him to Mir over the next two years will learn from his experience.

Perhaps the main surprise was the willingness of Thagard to voice the comments in such an open manner.

In any event Thagard's comments provided much food for thought for mission planners and hark back to comments made by Skylab commander Charles "Pete" Conrad way back in 1973. Conrad told reporters that he felt

comfortable having flown a mission of 28 days but said that if the mission controllers had told him that he would be staying in space for a longer period his problems would have been psychological, not physical.

Although he stated that he had mixed emotions about returning to Earth, Thagard made it plain that he had managed the four month flight with some difficulty and would have found it very difficult to undertake a six-month mission on the station.

Some years ago Soviet managers stated in a general manner that a four month long mission on the Salyut stations was optimal before cosmonauts began to lose interest and commitment.

Speaking about the 14 month mission of Dr. Valeri Polyakov, which ended with Thagard's arrival on the Mir station in March, the American said, in a jocular manner, that he wondered whether anyone who stayed that long on Mir could be "normal".

NASA Administrator Daniel Goldin admitted that little attention had been paid to Thagard's psychological needs in planning for the mission. Goldin vowed to rectify that situation for the future.



Gennadi Strekalov is shown the view from the Shuttle's aft flight deck windows by Atlantis pilot Charlie Precourt.

NASA (Supplied courtesy of ED HENGVELD)

Isolation

One of Thagard's major points was his "extreme cultural isolation." The doctor said that he missed his wife and three grown boys to a great degree and made a commitment to them that he would not undertake such a long separation from them again for a very long time.

Missing one's family is understandable, but Thagard went further. He voiced concern that he missed hearing American news and said that he often went for three days at a time without hearing an English voice and missed the chance to talk to NASA personnel at Houston on a regular basis.

He did speak with astronauts Shannon Lucid and John Blaha at the Kaliningrad Mission Control Centre (TsUP) on one occasion. The two are training for the next long-duration Mir mission due to start in March 1996, with Lucid as the prime candidate.

Thagard was also able to converse with radio hams via the Mir rig on many occasions. Before the mission ended, astronaut Jay Apt, himself a radio ham, thanked the ham community for their support of Thagard saying that their messages had helped him through difficult times during the mission.

For Vladimir Dezhurov, the historical

docking mission had an ending of mixed emotions. During the weekend of 17-18 June the cosmonaut's mother died, a message that was relayed to Mir and brought sadness to the trio.

Dezhurov was allowed two days of private mourning on Mir and close observers noted that during the joint flight he appeared often distracted during the events, even during his birthday celebrations - one of three birthdays during the flight.

(In 1978 cosmonaut Georgi Grechko returned to Earth after a 96 day mission to be told that his father had died during it - a fact kept from the cosmonaut until the landing.)

Food

Much comment was made about Thagard's reported dislike of the Russian space food. Thagard was noted by a NASA physician logging his intake as a gourmet and in post-flight comments the doctor himself admitted that he should have paid more attention to the food he was to consume.

However, Thagard asserted after the flight that the main problem with the food was the strict regime he had to follow before consuming any of it - a part of the science experiments. The astronaut had to record his daily intake to the gram using a bar-code reader and Thagard admitted that this was a "disincentive" to regular eating.

The result was that the doctor had lost almost 8 kg by early May of his normal 70 kg body weight.

Return to Earth

As noted earlier, the three Mir-18 cosmonauts returned to Earth on special reclining seats. They were expected to remain supine during the period when recovery teams removed them on stretchers to the waiting crew transport vehicle but Thagard stood up about 10 minutes after the landing of Atlantis on the Kennedy Space Centre runway and eventually walked to the van, Dezhurov and Strekalov kept the wish of the physicians.

Thagard said that initially he felt as though he was carrying a large weight on his shoulders.

All three men were taken to a medical lab and a brief, private, but intense reunion took place between the men and their families. (Thagard was given a hot fudge sundae by Daniel Goldin - a promise made by the administrator to the doctor.)

From KSC, and separate from the STS-71 crew, the Mir-18 crew was flown to Houston to another medical lab at the Johnson Space Centre where they were expected to stay during the period of prolonged medical examination.

But Norman Thagard, true to the character he had shown throughout the flight, turned down the offer of a medical lab bed and went home with his family.

He reported later he did not even feel as though he was floating, as he had done after his previous short shuttle trips, on his first night home.

The next day the medical tests continued on the Mir-18 crew at JSC and were to last for several weeks. ■

EuroMir 95

Intensive Training for an Ambitious Mission

EuroMir 95 will last a record-breaking 135 days and includes a spacewalk and some 40 scientific experiments. ESA astronauts Thomas Reiter and Christer Fuglesang will have received some 3,500 hours of mission training by the time of lift off.

EuroMir 95 will be the first time an ESA astronaut has had responsibility for the running and maintenance of space station systems, including the critical life support systems which keep the station habitable.

One of the most challenging aspects of the training programme has been preparing for the EVA to install sensors on a European experiment platform named ESEF (European Science Exposure Facility) mainly devoted to astrophysical investigations and fixed to the exterior of the Mir complex on the Spektr module. Reiter and Fuglesang have spent many hours practising working outside the station in a 20 m diameter, 12 m deep water tank at Star City. During these exercises they wear a specially modified space suit weighed down to simulate the 'weightless' conditions of space. Submerged mock-ups of Mir and its modules allow the astronauts to practice each step of the five-hour spacewalk.

Construction of most of the scientific equipment for EuroMir 95 has only recently been completed, so much of the scientific training has taken place this year. Much of the experiment training is taking place at ESA's European Astronaut Centre (EAC), saving time and cutting the costs of sending scientists and equipment to Russia.

ESA astronaut Thomas Reiter from Germany (left) training with the RMS 2 (Respiratory Monitoring System, second generation) at the Yuri Gagarin Cosmonauts training centre/Star City (near Moscow). Reiter will fly the EuroMir 95 mission together with Russian cosmonauts Sergei Avdeev (right) and Yuri Gidzenko.

The EuroMir 95 mission is scheduled for launch in September 1995.

ESA (Supplied courtesy Rolf H. Schoevaart)



Discovery Launched on STS-70

Record Six-Days From a Landing to Next Launch

The launch of Discovery on 13 July came just six days after the landing of Atlantis on 7 July. The previous shortest time of 10 days had been between STS-51D and STS-51B as well as between STS-61C and STS-51L.



The crew of Space Shuttle mission STS-70 gather in front of Pad 39B and Discovery for their families, guests and press on the afternoon before the launch (L to R): Kevin R. Kregel, Mary Ellen Weber, Nancy J. Currie, Terence T. Henricks and Donald A. Thomas.

JOHN MCKINNEY, AMERICAN IMAGE PRESS (Supplied courtesy PETER GUALTIERI, WEST KENTUCKY NEWS)

With only a few days until the final payload bay door closing for flight and a little more than a week until launch, it was found that woodpecker birds were busy digging holes into the insulation on the Space Shuttle's External Tank.

There were several concerns with the holes in the tank's insulation. After several days of analysis it was decided that the safest course for both the Shuttle and the workmen would be to roll the Space Shuttle back to the Vehicle Assembly Building for detailed inspection and repairs. Accordingly, on 6 June the IUS-TDRS was removed from the payload bay and the Shuttle was rolled back to the VAB on 8 June.

Repairs were completed and Discovery returned to the pad a week later on 15 June and the IUS-TDRS payload was reinstalled on 16 June.

The weather at the Kennedy Space Center was unusually bad on the evening of 10 July and the STS-70 astronauts, en route to KSC from their Houston base, were forced to land in Orlando, Florida and obtain a rental car to complete their journey to KSC.

The countdown proceeded with no concerns and as the morning of the 13th arrived the weather and the Space Shuttle continued to look good for launch. The flight crew departed their Operations and Checkout building quarters shortly before seven am, arrived at Launch complex 39B and began boarding Discovery about a half hour later. The hatch was closed and the sealing operation completed at about launch minus one hour and ten minutes.

The countdown proceeded through the last ten minute built-in-hold at T-9 minutes. At the resumption of the count the

terminal countdown began with the Ground Launch Sequencer starting the automatic sequence.

At T-7:30 the Orbiter Access Arm was swung away from Discovery's hatch. At T-3:30 power was transferred to internal. The count proceeded toward the T-31 second point, at which stage the Ground Launch Sequencer would send "go for redundant set launch sequence start" and the Primary Avionics Software System computers would take over main control of the count. The only further command from the ground at that stage is the "go for main engine start" at T-9.7 seconds.

Only seconds before reaching the T-31 second point, an engineer monitoring the destruct system for the boosters and External Tank noted a fluctuation in the External Tank range safety receiver automatic gain control. He quickly called a "hold" and ran a check of the system to verify the range safety system. The check showed the system was operating correctly and the countdown was resumed with a loss of only 55 seconds.

The countdown proceeded with no further issues and liftoff was at 9:41:55:020 am on 13 July 1995. The launch ascent went normally and on reaching an orbital altitude of 160 nautical miles the crew began configuring Discovery for orbital operations.

ROELOF L. SCHULING

About the Crew

See *Spaceflight*, May 1995, p.147.



Andrew Thomas.
PETER GUALTIERI,
WEST KENTUCKY
NEWS

Australian-Born Astronaut

Born in Adelaide, South Australia where his parents still live, Andrew Thomas is the final member of NASA's class of 1992 to be assigned a mission. Due for launch in April 1996, STS-77 will carry the Spacehab module and deploy the Inflatable Antenna experiment (*Spaceflight*, July 1995, p.248).

In 1973, Andrew Thomas graduated from the University of Adelaide, South Australia in mechanical engineering and obtained a doctorate in the subject in 1975. Since 1977 his employment has been in the USA at first in the aerospace industry and then, from 1989, at the Jet Propulsion Laboratory (JPL) shortly becoming appointed leader of the JPL programme for microgravity materials processing in space.

After being selected by NASA and undergoing one year of training, he was appointed a member of the astronaut corps and is currently assigned to support shuttle launch and landing operations at KSC as an astronaut support person.

'Cassini Spacecraft' Competition Winners

Winners to whom video prizes will shortly be dispatched are:

P. D'Angelo	Italy
G. Hutchings	England
D. Muir	Scotland
K. Pavitt	England
J. Solaz	Spain

The correct answers are: 1. B; 2. C; 3. F; 4. G; 5. J; 6. I; 7. A; 8. D; 9. E; 10. H.

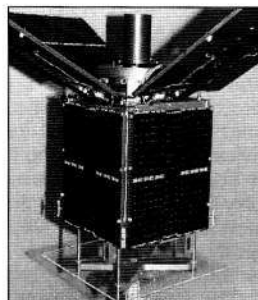
Microsatellite Launched

The CERISE microsatellite, using a satellite platform manufactured by Surrey Satellite Technology Limited (SSTL) for Alcatel Espace (France), was launched successfully on 7 July as a secondary payload on Ariane flight 75. CERISE is the ninth mission to use SSTL's modular microsatellite platform.

The next SSTL microsatellite scheduled to be launched is FASat-Alfa, built by SSTL for Fuerza Aerea de Chile. FASat-Alfa is scheduled to be launched in late August on a Ukrainian Tsyklon rocket from Plesetsk.

CERISE
ready for
launch.

SSTL

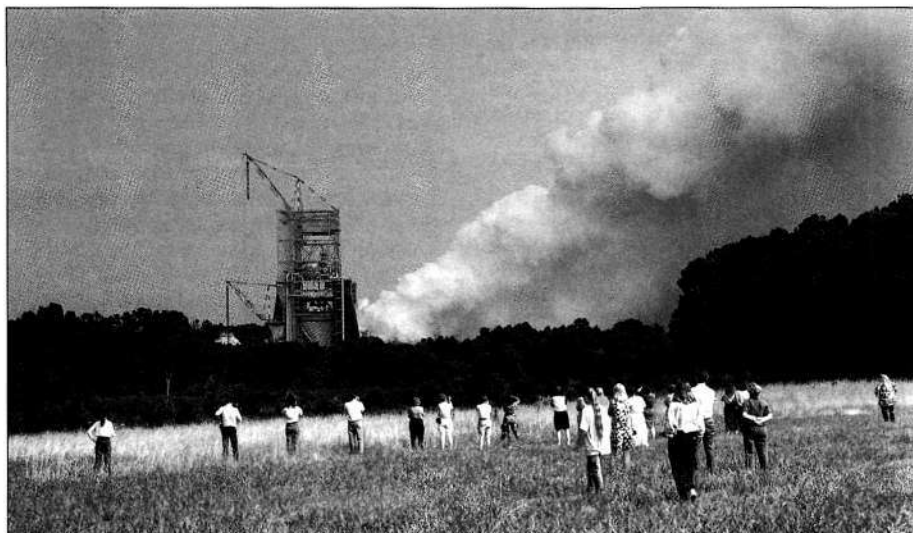


Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-73	21 September	Columbia	16 Days	USML-2	39
STS-74	26 October	Atlantis	8 Days	Second Mir docking	51.6
STS-72	30 November	Endeavour	10 Days	SFU-retrieval, OAST-Flyer	28.5
STS-75	15 February	Columbia	14 Days	Tether Satellite System-1R, USMP-3	28.5
STS-76	21 March	Atlantis	10+1 Days	Third Mir docking	51.6
STS-77	Late April	Endeavour	10 Days	Spacehab-4, TEAMS	28.5
STS-78	Late June	Columbia	14+2 Days	LMS	39
STS-79	August	Atlantis	9+1 Days	Fourth Mir Docking	51.6

New Space Shuttle Main Engine

In March 1995, NASA successfully completed testing a new high pressure liquid oxidiser turbopump for the Space Shuttle Main Engine (SSME). Along with the new turbopump, NASA has a new two-duct powerhead, which will significantly improve fluid flows within the engine system by decreasing pressure, reducing maintenance and enhancing overall performance of the engine. This new engine configuration is called the Block I engine.



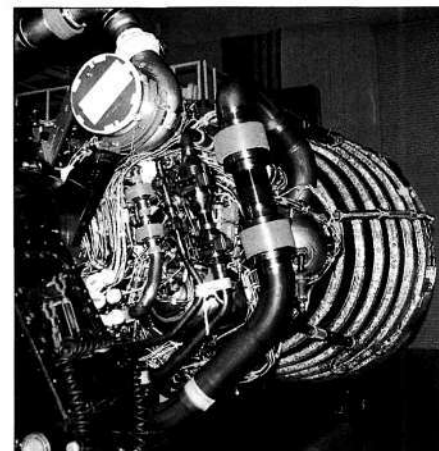
Onlookers at the Marshall Space Flight Center watch from a distance as the improved Block I Space Shuttle Main Engine (SSME) is test-fired for a planned three minutes on 21 June 1995. The test was a success.

E. RUDOLF VAN BEEST

On STS-70, one SSME was a new Block I engine. The remaining two engines were the current SSME design. The first flight planned to incorporate the new pumps into all three engines is STS-73, currently targeted for launch on 21 September 1995.

Right: The Block I engine features an improved heat exchanger, hot gas manifold and engine controller together with the new design of high pressure oxygen turbopump (HPOTP). The oxidiser preburner burns a fuel rich mixture to turn the HPOTP and can be seen to the lower left of the centre of the photo. The HPOTP is behind.

PETER GUALTIERI, WEST KENTUCKY NEWS



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SPACELINE



'Space Race' Continues

Sir, Having watched the (striking) footage of the Mir/Atlantis rendezvous today, I was struck by the phrase 'end of the Space Race' used by certain commentators.

If you think of the 'Space Race' as simply being between the US and USSR (as was), then this may well be correct. However, in a wider sense the 'Race' is still continuing - indeed, may be even more pressing.

It was H.G. Wells who remarked that the future would be a race between education and catastrophe. It was George Orwell who pointed out that civilisation had to be maintained, and that to maintain a thing was always to extend it.

From the moment of its creation, any 'organised structure', from a simple hut, to a complex civilisation, is under attack from the forces of entropy, trying to reduce order to chaos.

Western society is facing a wide range of 'negative' forces, internal and external, just as any human being does. Within the bloodstream are germs of a dozen diseases capable of killing, should they be allowed to multiply unchecked. In the past, the West has overcome war, famine, pestilence, etc, etc, but this is no guarantee that it will continue to do so. Societies have perished in the past, of course - none has absolute immunity.

In order to maintain our civilisation, we need to extend it, and the 'space frontier' is the area of that extension. The International Space Station will be a symbol of our continuing belief in our civilisation, our continuing belief that we have a future. In more practical terms, it will serve as the 'gateway' through which we will harvest the resources of the Solar System, giving us the ability to deal with many of the problems besetting us.

It need not necessarily happen that way, of course. It was Heinlein who pointed out that the laws of nature are not the exclusive property of any group or nation. I recently came across a report from the American Commission on Education, pointing out that, as the importance of trained workers to society increased, the standard of education was actually falling. A civilisation can collapse from the lack of people able or willing to sustain it, just as easily, if less spectacularly, as it can from North Korean warheads, or Iraqi plague viruses.

The race is still on: between those forces which enable our society to expand and flourish and those which would allow it to stagnate and die.

The race will never be over whilst humanity exists, but we can at least back the right side.

PETER DAVEY
Dorset, UK

Hardware Locations

Sir, *Spaceflight* readers may be interested in information concerning current locations of Soviet/Russian manned space capsules.

The Moscow journalist Sergey Shamsutdinov informs me that Soyuz-24, unflown Zond-9 (factory number 15) and unflown LK (manned lunar spacecraft) are located in the spacecraft laboratory of the Petersburg Military Space Academy (Mozhayskiy Academy). Soyuz-2 is at TsPK in the simulator hall of the Mir complex. Kosmos-110 (unmanned Voskhod, 3KV factory number 5), unflown Voskhod-3 (3KV factory number 6) and unflown Zond-10 (factory number 16) are located in the RKK Energiya exhibition hall.

Other sources give Vostok-1, Voskhod-1 and 2, Soyuz-3, Soyuz-19/ASTP, Soyuz-22, Soyuz T-3 and Zond-5 to be located at RKK Energiya, too. The Tsiolkovski memorial museum in Kaluga owns Vostok-5 and Soyuz-35. Soyuz-9 is believed to be at Sotshi on the Black Sea with Soyuz-28 in Prague, 29 in Dresden, 30 in Warsaw, 31 in Berlin, 33 in Sofia, 36 in Hanoi, 37 at the Korolyov memorial museum in Moscow and Soyuz T-6 in Paris.

I really hope, *Spaceflight* readers are able to supply more information.

UWE ZELTWANGER
Ingersheim, Germany

'Photo Opportunity' Risk

Sir, The Soyuz undocking before the Shuttle undocking from Mir always seemed an unnecessary risk to me, and to a lot of other folk, but the management wanted it for PR. And we seem to have survived, but barely.

Following Atlantis' undocking, the Mir attitude control system computer failed and the station began drifting out of attitude. The Soyuz faced the threat of not being able to redock if Mir got rolling too fast, perhaps under plume impact from Atlantis, more likely mostly just from aerotorques.

So the final portions of the Soyuz photo opportunity were cancelled, and it hurriedly redocked. By doing so, they saved the mission from a humiliating debacle, because a tumbling Mir would have been power-starved in a few hours and frozen dead, pretty well terminating plans for follow-on joint missions. And all for some "neat pictures"! We are not going to see the films until September at the earliest, and then probably only after buying them from the Russian Space Agency (who have never yet given us free pictures of Thagard's launch, or Spektr's launch - it is all for sale).

The Soyuz crew would have been able to land safely if they had not been able to redock, so there was no threat to life.

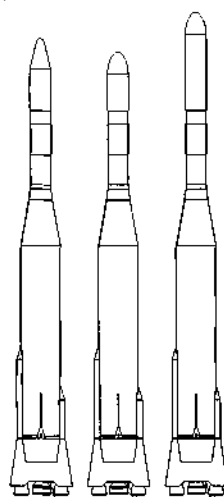
We dodged the bullet on this one. But it was stupid to step in front of the bullet in the first place, in my humble opinion.

JAMES OBERG
Texas, USA

Military Space Programmes

Sir, N.W. Watkins, in his letter in the August 1995 *Spaceflight* concerning the classified Atlas-Agena launches in the 1968-1978 period, is incorrect in saying that no photos of the vehicles have been released.

As early as 1984 such a picture was included in the Rockwell brochure "A past to build a future on", though it was uncaptioned. This brochure, incidentally, also contained the earliest released photo of an Atlas H launch that I know of. The Atlas-Agena photo showed a payload shroud similar in shape to but rather longer than the NASA Mariner/Lunar Orbiter Shroud. A second photo of this configuration was subsequently released identifying the launch date as May 1977.



A photo of a second configuration with a much longer shroud was discovered in unlikely circumstances by Joel Powell and Lee Caldwell and published in the Fall 1992 edition of the US space history magazine *Quest*. The existence of two different shroud configurations is further confirmation that two separate programmes were involved in these launches. My drawing above compares the two classified configurations with the only other Atlas SLV-3A, shown on the left, which was used by NASA for the OGO 5 launch. The large diameter shroud used for Seasat was a one-off using a refurbished ground test shroud from the Titan 3 programme.

A further snippet of information relating to these launches was in *Aerospace Daily* for 6 November 1969. This quoted USAF Lt Col Saavedra as saying that two Agenas had performed the coast to geosynchronous orbit, where they were providing power and attitude control to their payloads. Later classified launches seem to have left the Agena in transfer orbit, again indicating that two programmes were involved. There was considerable confusion in the press, never really resolved, as to whether the payload from the third launch had actually reached geosynchronous orbit.

The high level of classification of these missions is reflected in the conflicting orbital data that has been published for them, with the USA even supplying incorrect figures to the UN Registry.

G.R. RICHARDS
Hampshire, UK

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

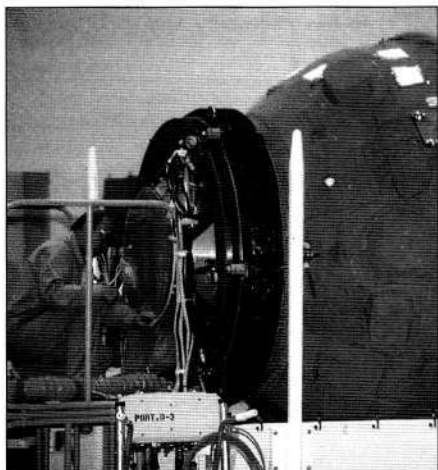
Russian Docking Module at Kennedy Space Center

Sir, I recently had the privilege of seeing the new Russian Docking Module for STS-74 at the Kennedy Space Center.

When the shuttle Atlantis approaches Mir for the second joint docking mission in October 1995, contact between the two spacecraft will be made with a new Docking Module built in Russia by NPO Energiya.

The 4.7 m module was unveiled recently in the gleaming (and nearly empty) new Space Station Processing Facility (SSPF) at Kennedy Space Center, tended by a team of Russian engineers from NPO Energiya. The docking Module (DM) is, in fact, the first payload to be processed in the SSPF, which was dedicated in March 1995.

Fitted with standard shuttle longeron attach fixtures, the module will be carried up to Mir by Atlantis on the STS-74 mission. Canadian astronaut Chris Hadfield, operating the Remote Manipulator System (RMS), will reposition the Docking Module atop the existing Orbiter Docking System

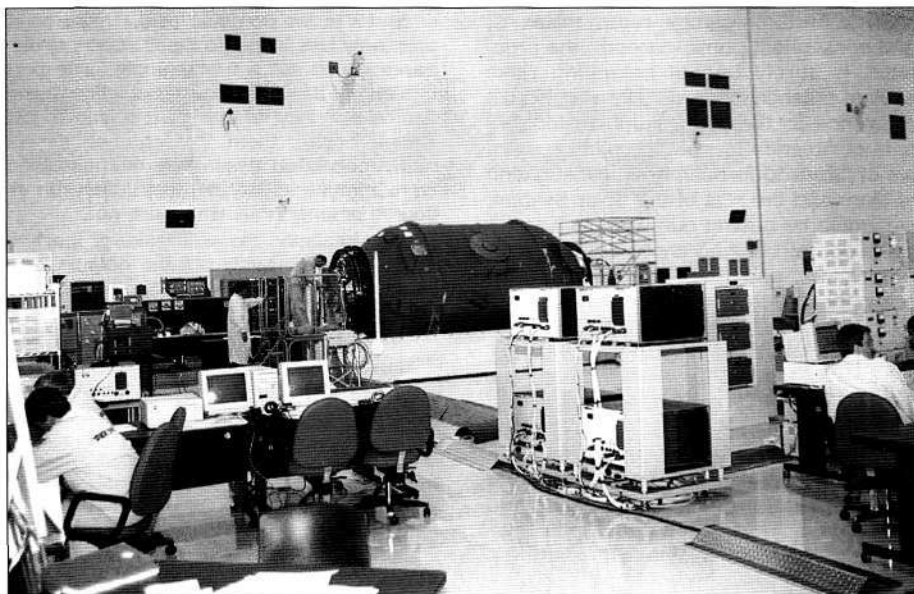


An NPO Energiya technician works on the docking interface (the hatch and the APAS). The guide ring for the APAS docking system is in the retracted position against the black ring. The white squares on the upper surface are covers for black dots to be used as targets in tests of the Canadian Space Vision System (SVS).

(ODS) prior to final approach to the Russian station. The module, which will remain permanently attached to the Kristall module docking port, will serve to extend the amount of clearance between Atlantis and the solar arrays of Mir after arrival of the Priroda science module later this year.

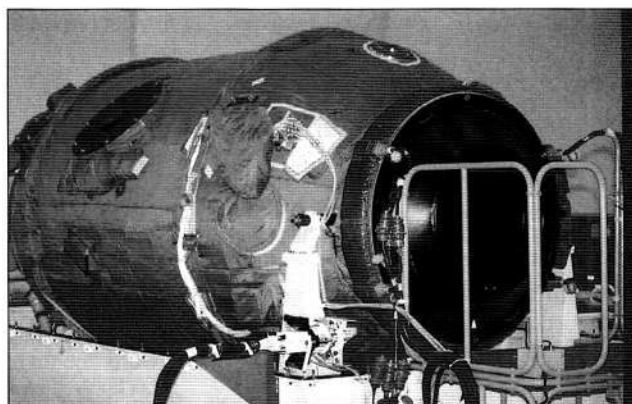
JOEL W. POWELL
Space Information Canada
Calgary, Alberta
Canada

(Photo credit: JOEL W. POWELL,
Space Information Canada.)



The Russian Docking Module (for STS-74) in High Bay of the new Space Station Processing Facility at KSC. This is the first payload to be processed there.

Right: At the right end of the module is the hatch for attachment to Mir-Kristall and hidden at the other end is the Shuttle ODS connection interface. The round cover at the centre of the cylindrical section is the solar array attach point.



Mars Contamination

Sir, In his article "Biological Contamination of Mars" (*Spaceflight*, April 1995), Isaac Grant Boxx raises some fascinating issues.

One question which he omitted to include is, however, crucial to the debate. This is Sir Fred Hoyle's theory that bacterial life is common on dust grains and comets throughout the galaxy. Together with Professor Chandra Wickramasinghe, he has argued vigorously for this theory in a whole string of books, of which the latest is *Our Place in the Cosmos* (Dent, 1993, library class 523.1), giving a neat summary on page 6 of that book:

Life on Earth is derived from an all-pervasive, galaxy-wide biological system. Life was derived from and continues to be driven by sources outside the Earth, in direct contradiction to new-Darwinian theory as it is generally understood.

Obviously, the question of whether in fact the planets are bathed in a dilute sea of bacterial or viral life has to be settled - whether by experiment or by dogmatic assertion - before the findings of life-probes on the surface of Mars can be interpreted.

Another issue which Mr Boxx's article raises is the use of the language "the biological contamination of Mars/of [other] Solar System bodies". This phrase sits awkwardly with the views of those of us

who believe that the whole point of going to Mars is to introduce Earth-life there! The word "contamination" plays into the hands of those extremists who would conjure up a vision of a state of natural purity - be it the Earth's "natural" (i.e. pre-technological) environment, or other planets "unspoiled" (i.e. unvisited) by spacefaring man - a purity which can only be degraded by sinful man, never improved upon.

On the contrary: I say we must assert that a living planet is infinitely preferable to a dead one - and one with a developed ecosphere such as our Earth preferable to a planet which supports life only at the minimum, bacterial, level - and that technological man is the emissary through which multi-cellular life may spread from one world in our Solar System to many.

Accordingly I propose that when we mean to talk about *the premature introduction of Earth-life* to Mars (i.e. before Mars has been adequately surveyed in its pre-colonial state) then we use exactly that language, rather than speaking of "contamination". (Obviously a scientist will be concerned that his sample of Martian regolith is not "contaminated"; but when used with reference to the whole planet the word "contamination" introduces the undesirable implications described above.)

When we move on to consider the possible accidental introduction of Martian

biota to Earth on sample return missions, and consequent public concern, the argument is surely one of balancing risks against potential rewards. Here Mr Boxx's reference to the pre-Columbian inhabitants of America is most instructive: were we in future to forbear from investigation of Mars and the rest of the Solar System, we would be putting ourselves in just the same position of ignorance as those early Americans, and therefore leaving ourselves equally vulnerable to external influences we would not understand. We must therefore continue to explore with the confidence that we can manage the risks that arise, as our civilisation always has done in the past. Within this overall view, the question of whether particular samples can be brought to Earth or should for the time being be kept in orbit or on the Moon can be settled democratically.

But if Hoyle and Wickramasinghe's revolutionary theory should be corroborated by the future sampling of comets and interplanetary dust, then the question of "contamination" of the Earth would disappear, for it would have been proved that it had been going on all the time! This is why experimental testing of their theory should receive priority over sending further life-probes to Mars itself.

Finally, Mr Boxx mentions that environmental groups have already shown a willingness to bring law-suits to stop space missions going ahead. I think it would be most useful to know more, and I hope that a subsequent article from Mr Boxx will give full details!

STEPHEN ASHWORTH
Oxford, UK

Isaac Boxx writes: I agree my article would have been better had it included a reference to Hoyle's Hypothesis, but when limited to just one page, there is only so much that can be said to stir debate on an issue.

I did mention in the article that the interchanging of material (possibly biological) between Earth and Mars has already taken place. And I must reiterate, the points I was making were solely about the biological contamination of Mars, not about the more general issue of life throughout the universe.

Your proposal that "we must therefore continue to explore with the confidence that we can manage the risks that arise, as our civilisation has always done in the past" also "plays into the hands of extremists" and raises some rather unpleasant possibilities if our historical tract record is to be taken into account. The only way mankind has thus far "managed" the risks of biological contamination in the past has been essentially to merely weather the storm, usually at the cost of millions of human lives. The most notable examples are the "Black Death" of the fourteenth century and the AIDS crisis of today. In the mid-fourteenth century, the Black Death struck Europe with such an unstoppable fury that it killed half the population before it wore itself out. There was no "management" at the time. And despite societies' best medical and scientific efforts since then to totally eradicate that plague (with full "confidence that we can manage the risks that arise"), there have been spontaneous outbreaks continuously ever since, with devastating results.

In the eighteenth century, when the British colonised Australia and North America, they brought with them viruses ranging from

smallpox to the common cold. These comparatively less lethal (to the Europeans) diseases wiped out a frighteningly large percentage of the indigenous populations, who had no immunity, at that point in time, to the viruses new to them. "Management of the risks" consisted essentially of those who were immune letting the destruction run its course among those who were not.

Most recently, the outbreaks of the two newest (but certainly not the only or last) viruses, Ebola and HIV/AIDS, have shown how futile it is to try to stop a new virus, once released, before its devastating effects and consequences are realised worldwide.

While I heartily agree with your assertion that ignorance is never the answer, I maintain it is sheer insanity to throw caution to the wind and just plunge in headfirst with little more than "confidence that we can manage the risks..." The view that we will leave ourselves vulnerable to "external influences" should be balanced by the fact that there is no justification for putting millions of lives at risk by introducing nonterrestrial organic material into Earth's ecosystem without considerable research, study over time and considerable deliberation. We have enough trouble handling the viruses we already have here on Earth, without recklessly introducing ourselves to more (under the guises of being "confident that we can manage the risks"... reducing the term "Contamination" to one supposedly being equal to "be degraded by sinful man, never improved upon"... asserting that a living planet is infinitely preferable to a dead one [unconditionally with no qualifications]...) to more. Clearly, further exploration of the planet is of paramount importance, but so is caution in doing so.

Your comments regarding my use of the word "contamination" are interesting and certainly give rise to contemplation. Is the word too strong? I do not think so. Imagine this scenario. Humanity has dedicated perhaps thirty years of continuous effort and billions of dollars, yen, pounds and roubles to get to Mars. Once there, the crew discovers a living micro-organism, perhaps a lichen or a cyanobacteria. After the announcement is made to the world and the ensuing euphoria has worn off, the question surfaces - did the micro-organism come from Mars or was it merely an earthbound species which survived the journey to the red planet? Once terran (Earth originated life is introduced to the Martian environment, it is forever too late to know for certain whether indigenous life ever existed there). It is in this context I use the word contamination. While many of us here on Earth may confidently assume we are the end all-be all to intelligent life forms, and that what we have to offer could never be degrading, damaging or of harm - indeed nothing but an improvement, that may not necessarily be so in the totality of the universe, nor even as far as Mars. Yes, "...technological man may well be the emissary through which multi-cellular life may spread from one world in our Solar System to many." But then again, he may not be. Let us not get too immediately carried away with our notion of our own significance, ego or sense of capacity. Without careful and ongoing research and debate into these crucial issues, that latter self could well and destructively overtake the former one, to our own harm as well as that of other bodies in space.

Unpleasant though it may be, I can think of no term other than "contamination" to adequately convey the importance and se-

riousness of this issue. To use a weaker or more socially pleasant term could allow the issue to be trivialised. That possibility or luxury we may wish to afford ourselves is unacceptable.

Finally, there is the moral issue of introducing terran life forms to the Martian environment. Some feel that it is amoral or even sacrilegious to place terran life on Mars. Contrary to what some may think or hope, this view is not only held by "extremists", but also by many persons holding the "middle of the road" line, within as well as outside the scientific world. Regarding information about legal action against major space agencies by environmentalists, I reference the lawsuit brought against NASA in 1989 by Rifkin and the Christic Institute in an attempt to block the launch of the Galileo Jupiter probe. The grounds for this suit were that if the space shuttle were to explode, the plutonium carried in the RTG power supply of the probe would be sprayed all over Florida. While the suit was ultimately unsuccessful, it was costly and damaging in its overall publicity to the space programme. Future lawsuits of a similar but more powerful sort could be even more damaging, and worse, successful, particularly if public opinion were swayed in favour of the opponents of space exploration.

Questions relating to biological contamination must not only be raised, but answered, whether by experimentation or debate. I hope other members of the British Interplanetary Society will pose as interesting and challenging questions and counterpoints and thus add their own ideas and points to this necessary and important debate.

Next Issue. . .

Communications Satellites

*To mark the 50th anniversary
of the concept of
geostationary satellites
advanced by*

Arthur C. Clarke
in October 1945

* * *

Space Technology and Applications

*Recent developments, including
communications satellites, as
revealed at the Paris Air Show*

* * *

Space Shuttle

*Upcoming launches . Previews
. Status and mission reports .*

* * *

Apollo 13 Motion Picture

Reviewed for UK general release

Filming of the "Apollo 13" Motion Picture

Peerless Voyage

NASA's "Finest Hour" Comes to the Silver Screen

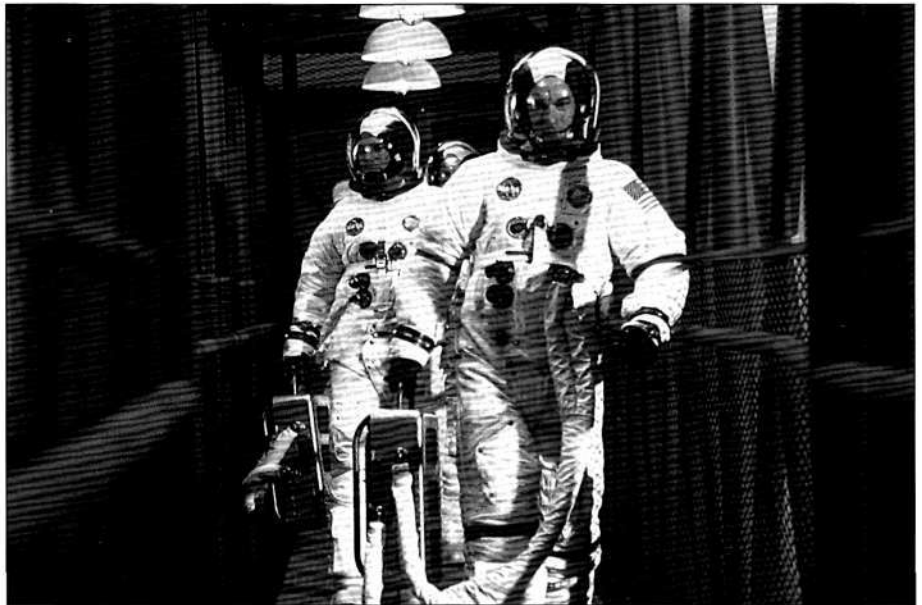
Backed by the sort of budget (\$52 million) with which NASA is actually planning to return to the Moon, the film *Apollo 13* opened to rave reviews and instant box-office success in America at the end of June. The movie reaches these shores on 22 September when it is due to go on general release across the UK.

As was reported in the February 1995 edition of *Spaceflight*, the film stars Tom Hanks as Jim Lovell and is directed by Ron Howard. Filling out the remainder of the crew roster are Kevin Bacon as Jack Swigert and Bill Paxton as Fred Haise. Top billing is also shared with Ed Harris, who plays the legendary flight director Eugene Kranz. Also waiting anxiously back home on Earth are Kathleen Quinlan as Lovell's wife Marilyn, and Gary Sinise, who portrays the unfortunate Ken Mattingly, the man who was pulled from the crew at almost the last moment.

Let's not make it any worse by guessing

The crew of Apollo 13 originally began working on an account of their aborted Moon flight shortly after returning safely home. However, the trio soon went their separate ways as they took on new assignments and so nothing ever came of the project. It was not until 1992 that Commander Jim Lovell joined forces with science

Unlucky for some: The problems begin to mount for Lovell and Haise in *Apollo 13*.



All dressed up: For Tom Hanks, the star of Universal's *Apollo 13*, the chance to play astronaut Jim Lovell was a "dream come true".

BY DARREN L. BURNHAM
Oxford, UK

writer Jeff Kluger to begin work on *Lost Moon*, his own account of the flight.

Though Lovell's and Kluger's book was at the time nothing more than a single draft chapter and a brief outline of the remainder, a four-way tussle nevertheless ensued for the film rights, with Kevin Costner's production company being one of those involved. The highest bidder turned out to be Imagine Entertainment, the independent production company jointly run by producer Brian Grazer and director Ron Howard. Imagine snapped up the rights for a comparatively modest \$650,000 with a view to producing a movie in collaboration with Universal.

Given his earlier interest in the project, Universal initially offered the starring role to Costner, but when it became clear that he was committed to *Waterworld* they turned instead to Hanks. The actor was thus re-united with the director who had helped launch his movie career, since they had worked together on *Splash* ten years previously.

It's rather odd to see us floating like this

The 41 year old director soon had to confront the vexatious problem of re-creating the effects of zero-G with some degree of verisimilitude in a one-G environment. Rejecting the wire

work and fake slow motion shots which have featured in previous astro-pics, initial scenes were shot at Universal Studios in Hollywood with the spacecraft set turned upside down and the actors suspended inside. Some of the footage made its way into the final cut, but it was not an ideal solution as the "actornauts" (as they were nicknamed around the studio) found it hard to work in such conditions with the blood pooling in their heads.

Howard improvised by asking NASA's permission to film a number of key sequences in the KC-135 "Vomit Comet". They agreed to the request and a total of ten days filming took place aboard the modified 707 aircraft, snatching takes during the brief period of 25 seconds of weightlessness achieved at the apex of the each parabolic flight. Howard was so impressed with the results obtained that he returned to Houston at the end of principle photography to shoot a further batch of weightless scenes. These additional sorties took the number of parabolas flown by the cast and crew to over 600.

The simulation of zero-G aside, another problem which the team faced was the fact that a large proportion of the audience would have vivid memories of the flight. Howard and cinematographer Dean Cundey decided early on that they did not want *Apollo 13* to look like a documentary, conceding that there was no way that they could make the results as authentically bad



25 years after Jim Lovell broadcast the theme of 2001 - *A Space Odyssey* from trans-lunar space, the mission of Apollo 13 has itself become the subject of a major motion picture. NASA

as the grainy TV images originally transmitted back to Earth. Instead they opted to exploit the full potential of the widescreen format so as to emphasise the claustrophobic confines of the spacecraft.

The replica spacecraft and spacesuits were created by KCSC Space Works, Inc., a Kansas based operation run by Max Ary which specialises in the refurbishment of space hardware and the construction of replicas for museum exhibition. In addition to the sets used on the KC-135 flights, two replicas were built of both the Command Module Odyssey and the Lunar Module Aquarius for use in the studio. Each was modular in design, making it possible to remove panels so that scenes inside the cabins could be shot from a multitude of angles. The camera crew also developed a technique which they dubbed "zero-G cam". It was similar in principle to the rigs used to prepare Apollo crews for lunar surface EVA's and involved suspending a camera on a pulley and counterbalance to give the camera the illusion of weightlessness. In a nod to method acting, the soundstage was also refrigerated to 38 degrees to add authenticity to the recreation of the tense ride home in the frozen LM.

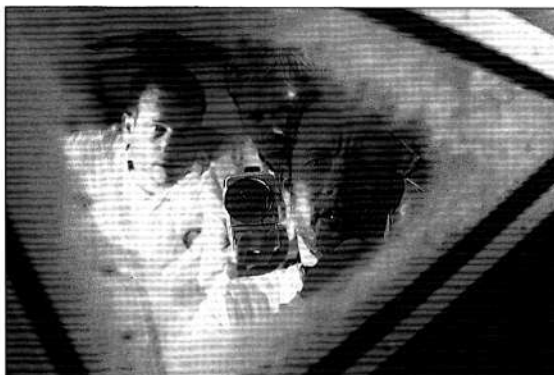
Though it is inevitable that the film should have been embellished with the occasional movie "moment" and that one or two facts have been jettisoned so as to condense the story down into a 140 minute movie, it was the stated intention of those involved to play it straight and let the real-life drama of the situation talk for itself. In the words of producer Brian Grazer 'What happened in this mission, you could never have dreamt up, but it's all absolutely true. We are obligated to capture it and present it in an unequivocally authentic manner.' Grazer's views are shared by his leading man, who describes Thirteen's voyage home against all the odds as a 'saga as great as anything the Greeks put down on paper, or any story from

Shakespeare or the Bible.'

To help the pursuit for perfection, Lovell assisted during pre-production and initial shooting which commenced last August. When he left to undertake a tour to promote the book *Imagine* hired Apollo 15 Commander Dave Scott to serve as technical consultant on the set. Former flight controllers Gerry Griffin and Jerry Bostick (father of Mike Bostick, *Imagine's* Senior Vice President) also added their expertise.

Rocketship 508

The special effects sequences came courtesy of Digital Domain, with a team of about 40 digital artists working under the supervision of Rob Legato. The film features about 125 effects sequences (whereas a full-blown sci-fi/fantasy blockbuster might employ up to 300 such sequences). The team had cut its teeth on the *Star Trek - The Next Generation* TV series,



Blue Moon: the imperiled "actornauts" of Apollo 13 peer out of gloomy confines of the Aquarius.

but *Apollo 13* was an altogether different proposition. The audience will accept almost any old hokum in science fiction, but a film such as *Apollo 13* must rise to the greater challenge of remaining faithful to the real-life story (a point which can be underlined due to the fact that the American space history magazine, *Quest*, even went so far as to offer a prize to the reader

who sent in the longest list of verifiable errors seen in the film!).

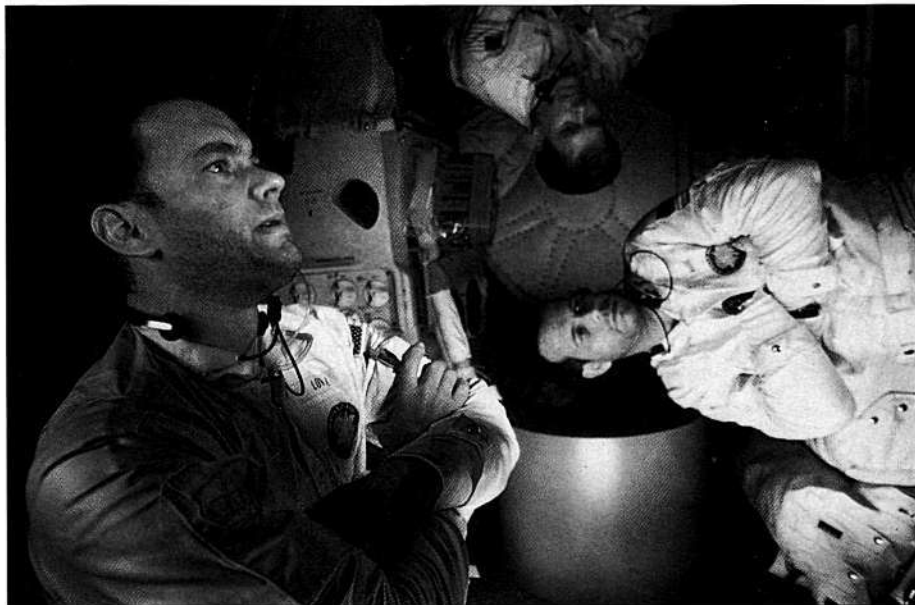
By far the biggest challenge was recreating the majesty of the Saturn V launch. After rummaging through the NASA film archive it was concluded that the inclusion of some of the pale, inconsistent stock footage of actual Saturn V launches would only devalue the impact of the finished film. Thus it was decided to recreate the event using state of the art computer graphics.

Much of the launch sequence featured a 1/20th model of the Saturn V and launch gantry. The backdrop came courtesy of a series of overlapping shots taken at KSC last summer. Back at Digital Domain's California workshops the images were scanned and merged into a motion picture, rather like the short movies generated from the TV images sent back by robotic planetary spacecraft. The raw footage was then massaged to remove any sign of the past 25 years of progress (such as the Shuttle launch gantry) and the model shots superimposed in their place along with gas, ice and fire to produce the final composite.

In its publicity material, Universal proudly boasts that the film is entirely original and that there are no shots lifted directly from footage taken during the actual Apollo missions. The payback from all this work is that it did allow the filmmakers more freedom in creating sequences which suit the mood of the film than might have otherwise been the case. For example, one notable sequence designed to bring home the sheer size of the space hardware involved is a unique overhead shot of the Saturn V in construction in the VAB.

A completely different set of challenges arose once the spacecraft was seen to actually arrive in space. The view of a spacecraft travelling through

Getting to grips with the gravity of the situation: (Anti-clockwise from bottom left) Tom Hanks (Jim Lovell), Tom Paxton (Fred Haise) and Kevin Bacon (Jack Swigert).



"Apollo 13" Has US Preview

the unending blackness of space could have looked fairly static on screen. Legato thus rolled the camera to match that of the spacecraft in barbecue mode, so as to continually provide a point of interest for the eye.

For the explosion sequence the team built a full size section of the Service Module. An hydraulic ram was used to simulate the energy of the explosion, with fire extinguishers being used to simulate the oxygen venting into space.

The climatic re-entry sequences involved the use of a large scale model of the Command Module with a replica heat shield. With the model bathed in flame, the sequences were shot at four seconds per frame so as to recreate the hazy appearance of the plasma sheath. Further character was added with vapour trails generated by computer and the occasional puff from the fire extinguisher.

The Individual Still Counts

These are some of the technical aspects of the filming of a movie which led the US box-office over the high profile July 4th holiday weekend, taking \$65 million in the first two weeks of its North American release alone. But in common with the real mission, it is the "human" interest angle which has received most attention. With Hanks having received consecutive Best Actor Oscar's for his roles in *Philadelphia* and *Forrest Gump*, the question on most movie critics' lips has been whether he will score an unprecedented hat-trick with *Apollo 13*? The early indications are that Hanks looks like a safe bet for at least an Oscar nomination, but that the ultimate prize may yet allude him. Not that his performance in *Apollo 13* is any less than impressive than *Philadelphia* or *Gump*, its just that he is not required to carry '13 to the same extent as his

Art imitates real-life: The reality being that June's Atlantis-Mir docking was invariably left trailing in the wake of the media blitz which surrounded the release of *Apollo 13* in the US. Few predict that the commercial success of the film will provide any noticeable boost for NASA's fortunes.



Apollo 13 LMP Fred Haise signs autographs at the gala reception at Merritt Island, Florida prior to the exclusive preview showing of the *Apollo 13* motion picture on 28 June 1995.

SPACE INFORMATION CANADA

Joel W. Powell writes: The movie was a great testament to the Apollo era, and the Apollo 13 mission in particular, complete with a cliffhanger ending that was very emotional. Bravo Ron Howard!

Prior to the screening a gala reception was held to raise funds for the "Save Our

Human Space Programs" campaign, a project of local and civic groups and aerospace companies. Later I visited the Universal Studios theme park where props from the movie are featured in a large *Apollo 13* attraction (across the way from "Casper the Friendly Ghost").

two previous outings, a fact which may mitigate against his chances of another Oscar. He may be earning a reported \$13.5 million basic fee plus a percentage of the box office returns, but in the best traditions of the space programme, Hanks is just "one of the guys", for *Apollo 13* is very much an ensemble piece in which everyone has their part to play.

One thing is for sure, if Hanks does waltz off with an Oscar for *Apollo 13* then nothing would give him greater pleasure. A self-confessed astro-buff (he could even reel off the names of the Apollo crews long before he started work on *Apollo 13*), Hanks had

even considered bringing the story of what many regard as NASA's "finest hour" to the screen himself, and signed on the dotted line almost as soon as Imagine sent him the first draft of William Broyles and Al Reinert's script. So will he have to suffer the disappointment of having the ultimate prize snatched out of his hands so close to fulfilment? Perhaps he had better compare notes with Jim Lovell on that score.

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Quest, Vol. 4 No. 1, Spring 1995.

Acknowledgements

Louise Harrow, United International Pictures (UK), and Jean-Michel Nadeau.

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BIS News

Gifts to the Society

The BIS Development Fund is well utilised every year and we need to start it off at a good level for 1996. Individual donations of varying amounts are the main source of income to this Fund.

Members will shortly be receiving a Membership Renewal Form for 1996 and with it the opportunity to send a contribution. We know from previous years that every little extra counts, so please help as much as possible particularly as our subscription rates remain unaltered for the second year running.

For those with a UK bank account, payment by direct Debit conveniently takes care of membership renewal. Direct Debit forms are available from the Society for those who do not already use this service or for those who do so and would now like a regular annual donation to be included with the payment.

For those who pay UK income tax, the Society can claim a tax refund on regular annual payments to the Society at no cost to the member. Please send to the Society for a copy of the simple Deed of Covenant Form.

For larger donations from UK income tax payers, the Society can claim a tax refund on single donations under Gift Aid, the requirement being that the amount donated exceeds £250.

From time to time the Society receives valuable support in the form of bequests. Such arrangements can be made quite easily by a simple clause in either a Will or Codicil reading as follows:

"I give, devise and bequeath to the British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, the sum of £... (followed by the amount in words) free of duties".

Those wishing to support the Society in either of the last two ways and needing further information should write to the Executive Secretary.

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'As It Happened - Moon Landing'

Channel 4 Video, 1995, Running Time 90 mins
Available from any good video stockist. Price £10.99

This film was made in 1994 for Channel Four and the Discovery Channel and was screened on C4 in December that year. Like the majority of TV programmes and films that were made to commemorate the 25th anniversary of the Apollo 11 Moon Landing it is not primarily concerned with the science, engineering and technology necessary to get man safely to the surface of the Moon and back to Earth. It seeks to present the human story, that is to examine the underlying motives, the intellectual and ethical drives and the human emotions that underpinned the commitment to the Apollo programme and contributed to its spectacularly successful culmination.

The film sets out to achieve some measure of understanding as to why, so soon after such a crowning achievement, things rapidly went wrong with the belief and commitment to the goal-oriented programme of manned space exploration. To a large extent, space exploration itself was largely abandoned to be replaced by a deep disillusion with manned exploration of the Solar System which has lasted right up to the present day. Few would have believed in 1946, the first year after the end of the Second World War when the world economy had been virtually brought to its knees, that in 23 years time man would land on the Moon. In the 23 years that have elapsed since the last Apollo 17, a period throughout which the world economy has been incomparably richer, there has been no firm recommitment to continue the manned exploration of the Moon, still less to go to Mars. This film clearly shows those who were involved in Apollo still have an enduring belief and commitment to the idea that man's destiny is out there, first among the planets and then amongst the stars.

That being said, how close does this film come to achieving its aims? The answer is that it comes very close indeed. The real strength of this film lies in the way it unfolds the history of the Apollo programme from the challenging announcement by President John Kennedy of America's intention to go to the Moon within a decade to the closing images of the now abandoned, derelict and decaying Apollo launch pads conveying the loss of outward looking vision that seems to have infected governments all over the world.

A large part of the impact of 'As It Happened' comes from the thoughts, reactions and opinions about the Apollo lunar landing programme that are so clearly expressed by Apollo astronauts Jim Lovell and Frank Borman (both Apollo 8), Rusty Schweickart (Apollo 9), and above all by Buzz Aldrin (Apollo 11). On their return to Earth, Buzz Aldrin noted that while he, Armstrong and Collins were confined to the quarantine unit they were shown tapes of the TV coverage of the mission. While watching the taped event he remarked to Armstrong that they had 'missed the whole thing'. In that moment Aldrin says he realised that what happened on Earth in the minds of the witnesses to the event was the really important thing. As he puts it 'the really important thing didn't happen on the Moon it was the realization in the minds of all those witnesses that man can do such things'.

This film is not just a history of an event



Buzz Aldrin, Lunar Module pilot, descends the steps of the Lunar Module ladder as he prepares to walk on the Moon. NASA

which, in the words of Arthur C. Clarke, 'May be the only achievement by which our age will be remembered 1000 years from now', it is a story of how we can come to do the right thing for the wrong reason. The politics of the Cold War provided the drive for the demonstration of superior technology and the Apollo programme was the theatre for that demonstration.

'As It Happened - Moon Landing' is an impressive and at times a deeply moving film. I can only hope that it will make the present generation of political decision makers who currently are obsessed just with looking at the dust around their feet lift their gaze to the high frontier of exploration. Humanity needs a challenge, we do better when trying to reach for things that appear to be just beyond our grasp. To settle for less is not to be content with second best it is to accept decline. The Apollo programme teaches us that we need both individual and cooperative effort to achieve great things and that almost anything is possible for us if we wish it to be so. In spite of the present general lack of conviction those of us who continue to believe in a human future in space - the manned exploration and even the colonization of other worlds - know of one thing we can be sure - you cannot fight against the future - time is on our side!

RICHARD TAYLOR

'Apollo 13 Mission' Competition

See p.323 for entry details to this month's competition which offers as prizes six copies of the 'As It Happened - Moon Landing' video.

'Apollo 13 Mission' Competition

This year has seen the 25th anniversary of the Apollo 13 mission which was crippled by an explosion on the way to the Moon. The story of this mission has been told by commander Jim Lovell in his book 'Lost Moon' and has been made into a movie which is due for release in this country in September having already been well received in the USA. This month's competition strikes a topical note and looks out a few facts that went along with the events of the mission.

Prizes: The first six correct entries to be opened after the closing date of 5 October 1995 will receive a copy of the following video*:

'As It Happened - Moon Landing'

For a review of this video please see the opposite page.

To Enter: Answer A, B or C to each of the following three questions, using each of these letters once:

- In the official crew picture shown on the right, the astronaut who did not take part in the mission sits:
 - On the left
 - In the middle
 - On the right
- As a result of the explosion, there was a loss of normal supply of:
 - Propellant
 - Breathable atmosphere
 - Electricity and water
- The spacecraft passed the Moon at a distance of about:
 - 200 km
 - 2000 km
 - 20000 km



Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 5 October 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

*Tapes are VHS PAL format only and are not compatible with the US NTSC system.

Title/Name

Address

.....

.....

.....

Spaceflight Crossword

No. 25

ACROSS

- French astronaut
- Mars lander
- New Mexico launch site for Goddard
- Soviet communications satellite first launched in 1976
- Chimp who orbited in Mercury capsule
- Apollo astronaut
- Clutches
- Glide along near surface
- Name given to the first short-period comet
- Name given to a frequency change effect
- Satellite of Uranus
- Small asteroid that gets nearer to the Sun than Mercury

DOWN

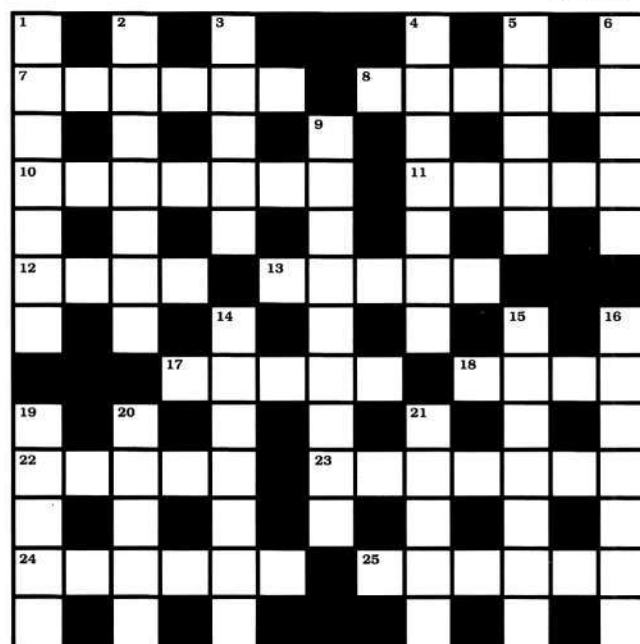
- Stopped, for example a launch
- Mark on solar disk
- Command
- Bell 7
- Daily record
- Rocket upper stage launched on an Atlas rocket
- It absorbs perfectly (5,4)
- Name given to formerly proposed space station
- British upper atmosphere sounding rocket
- Stamp
- Ancient story teller
- Spiral ridged fixing device
- Territory where astronauts travel

Solution will appear in the October issue.

Solution to Crossword No.24.

ACROSS: 1. Operate; 5. Titan; 8. Brews; 9. Shepard; 10. Theatre; 11. Drawl; 12. Detour; 14. Ryumin; 17. Child; 19. Illegal; 22. Illness; 23. Grain; 24. Gyros; 25. Nuclear.

DOWN: 1. Orbit; 2. Element; 3. AMSAT; 4. Easter; 5. Tuesday; 6. Tiara; 7. Nedelin; 12. Docking; 13. Undress; 15. Magnate; 16. Gibson; 18. Idler; 20. Logic; 21. Lunar.



SATELLITE DIGEST-280

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Cosmos 2313	1995-028A	Jun 8.20	Tyuratam	Tsyklon-M	3,000 ?	Jun 8.83	65.04	92.77	403	418	[1]
DBS 3	1995-029A	Jun 10.02	Kourou	Ariane 42P	2,934	Jun 25.43	0.01	1,436.07	35,777	35,795	[2]
STEP 3 (P92-2)	None	Jun 22.83	WR	Pegasus XL	268	Failed to reach orbit					[3]
Atlantis	1995-030A	Jun 27.81	KSC	Shuttle	97,387	Jun 29.68	51.64	92.48	392	400	[4]
Cosmos 2314	1995-031A	Jun 28.77	Plesetsk	Soyuz	6,500 ?	Jun 29.94	67.13	89.56	166	340	[5]

NOTES

1. EORSAT ("ELINT Ocean Reconnaissance Satellite") launched to operate with Cosmos 2293 (1994-072A). Tsyklon-M launch vehicle also referred to as Tsyklon-2 in Russian/Ukrainian literature.
2. DBS 3 ("Direct Broadcast System") is an HS-601 communications satellite to be operated by Hughes Space and Communications Inc. Mass of the satellite quoted above is at launch: on station it is 1,707 kg and the dry mass is 1,259 kg. Satellite deployed over 248-249 °E.
3. STEP ("Space Test Experiment Program") satellite carried five experiments: ACTEX ("advanced controls technology experiment"), EDMM ("erasable disk mass memory"), SAMMES ("space active modular materials experiment"), SAWAFE ("satellite attack warning and assessment flight experiment") and SQUOD ("space qualified optical disk"). Planned orbit was circular at 450 km (no orbital inclination available). Stargazer L-1011 Tristar took off from Vandenberg Air Force Base approximately 19.00 GMT on June 22 and deployed Pegasus XL at 19.58 GMT. First stage fired as planned but the failure of a second stage interstage ring to separate as planned resulted in Pegasus being destroyed at an altitude of 144 km by the Range Safety Officer. This was the second launch of a Pegasus XL variant and the second launch failure (the previous flight was June 27 1994 and carried STEP 1).
4. First Shuttle-Mir Mission (SMM-01). Carried five astronauts and two cosmonauts into orbit on the first shuttle mission to dock with the Russian Mir Complex: at launch the crew comprised R.L. Gibson (commander), C.J. Precourt (pilot), E.S. Baker (mission specialist, MS1), G.J. Harbaugh (MS-2), B.J. Dunbar (MS-3), A.Y. Solovyov (new Mir commander) and N.M. Budarin (new Mir flight engineer). Mass quoted above is that projected at the time of landing. Orbiter carried a docking module for Mir operations (mass 1,822 kg), a SPACELAB module and transfer tunnel (mass 858 kg) and SPACELAB payloads (2,603 kg) in its payload bay. Atlantis docked at the front longitudinal port of the Kristall module attached to the Mir Core module June 29.54. Crew transfer to Mir Complex began approximately 90 minutes later. While docked Atlantis/Mir Complex was the most massive assembly in orbit (approximately 223 tonnes) and was housing the largest number of people in one place (6 US astronauts, 4 Russian cosmonauts). After nearly five days of joint operations the five Americans launched on the shuttle together with astronaut Thagard and cosmonauts Dezhurov and Strekalov (launched aboard Soyuz-TM 21 and working on the Mir Complex when Atlantis arrived) transferred to the orbiter, while the new Mir crew of Solovyov and Budarin moved to Soyuz-TM 21. The Soyuz-TM undocked from Mir to permit photography of the Atlantis separation which took place July 4.47. Atlantis returned to Kennedy Space Center July 7 while Solovyov and Budarin remain in orbit until Soyuz-TM 21 returns to Earth in September.
5. "Yantar" fourth generation, close look photoreconnaissance satellite. Satellite releases data-return capsules during its mission with the main re-entry module being recovered when the flight is terminated after a lifetime of 60-70 days.

ADDITIONS AND UPDATES

- | | |
|--|---|
| <p>1967-043B Hitchhiker 14/OPS 1967 decayed 1993 Mar 14.</p> <p>1986-017 Further details of the relocation of modules docked as part of the Mir Complex can be given. The relocation of Spektr (1995-024A) from the +X port of the Mir core module to the -Y radial port took place approximately June 2.8. Kristall (1990-048A) was relocated from the -Z port to the +X port during June 10 where it remained during the Atlantis docking mission (see 1995-030A above).</p> <p>1986-026B BRASILSAT A2 was manoeuvred off-station over 294-295 °E approximately June 19: the satellite was still drifting at the end of the month.</p> <p>1988-091B TDRS 3 was manoeuvred off-station over 188-189 °E. The Two-Line Orbital Elements suggest that the satellite drifted as far as 53 °E by June 7, but by June 16 the satellite's longitude had been re-stabilised over 84-85 °E.</p> <p>1989-070A Himawari 4 was manoeuvred off-station over 139 °E approximately 1995 June 9: the satellite was still drifting at the end of the month.</p> <p>1990-061A Cosmos 2085 drifted off-station over 79-80 °E at the end of February 1995 and has not re-stabilised its orbital longitude through to the end of June: it is therefore assumed that the satellite has ceased operating.</p> <p>1990-054A Gorizont 20 re-stabilised its orbital longitude over 25-26 °E approximately June 9.</p> | <p>1993-044A Cosmos 2258 decayed from orbit 1995 June 8.</p> <p>1994-053A Following its de-orbit manoeuvre debris from Cosmos 2290 decayed from orbit 2,720 km north-east of New Zealand 1995 April 4.75.</p> <p>1995-010A The two cosmonauts Dezhurov and Strekalov and the astronaut Thagard undocked from the Mir Complex July 4.47 aboard the United States space shuttle orbiter Atlantis (1995-030A, see above): returned to Earth July 7. The new resident crew for Mir - Solovyov and Budarin - were taken into orbit aboard Atlantis, launched June 27. Soyuz-TM 21 with Solovyov and Budarin on board undocked from the Mir Complex/Kvant 1 -X port July 4.45 and retreated to a distance of about 100 metres to photograph the undocking of Atlantis: the Soyuz-TM re-docked at the -X port July 4.49.</p> <p>1995-011B During 1995 June 5-18 Himawari 5 was relocated from 159-160 °E to 140 °E: no Two-Line Orbital Elements were issued which permit the manoeuvre dates to be estimated.</p> <p>1995-025A Add the following orbital data for GOES 9:- June 4.78, 0.24°, 1,436.06 minutes, 35,651 km, 35,921 km. The satellite has stabilised its orbit over 269 °E.</p> <p>1995-027A Add the following orbital data for UFO 5:- June 10.29, 5.09°, 1,436.28 minutes, 35,060 km, 36,520 km. The satellite is located over 189 °E.</p> |
|--|---|

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

6 September 1995 7 - 8.30 pm

STRV Satellites: Mission and Results

Dr Andrew Sims

DRA Farnborough

On 17th June 1994, two small satellites built by the Defence Research Agency were launched from Kourou, French Guyana as auxiliary payloads on Ariane flight V64. Placed into Geostationary Transfer Orbit, the mission of the two 52kg "Space Technology Research Vehicles" is to demonstrate the in-orbit performance of novel technologies and to make supporting measurements of the space environment. The talk will focus upon lessons learned from the new technologies - both during development and in-orbit and on results from a variety of radiation monitors flown on both satellites.

16 October 1995 7 - 8.30 pm

ESA's ARTEMIS Mission: An Operational Test of Ion Propulsion

Dr D.G. Fearn

DRA Farnborough

Ion propulsion, the "ion drive" so often mentioned by science fiction authors, is soon to have an opportunity to demonstrate its capabilities on ESA's ARTEMIS experimental communications satellite. Ion thruster systems from the UK and Germany will be used for operational north-south station-keeping for the 10 years life of this satellite. The lecture will explain the principles behind this technology and will then describe its application to communications satellites, concentrating on ARTEMIS and pointing out the resulting operational and financial benefits.

1 November 1995 7 - 8.30 pm

Mini Black Holes

Bernard Carr

Queen Mary & Westfield College

Small black holes may have formed in the early Universe when the density was very high. Such primordial black holes are of particular interest because they are the only ones small enough for quantum effects to be important, those smaller than 10^{15} g having evaporated by now as a result of the Hawking process. We discuss their possible observational consequences.

22 November 1995 7 - 8.30 pm

SAREX

Mr Will Marchant

The Shuttle Amateur Radio Experiment (SAREX) is an amateur radio station flown on about half of the NASA Space Shuttle Missions. It is primarily used for contacts between the astronauts and school students during the

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- ✦
- Lessons from the design, development, construction, launch and operation of the UoSAT satellites
- ✦
- The STRV Spacecraft: platform design overview and flight experience
- ✦
- The STRV Spacecraft: an overview of experimental results
- ✦
- The SIL spacecraft designs and associated technologies
- ✦
- The application of low-cost spacecraft to science missions
- ✦
- Low-cost interplanetary applications using ion propulsion
- ✦
- The UoSAT mini-satellite concept
- ✦
- The ARGOS high energy upper stage: a way of augmenting the limited capabilities of small launchers

Registration forms are available from the Executive Secretary.

mission. The speaker will present a SAREX related slide set that he has created for use by NASA Educational Personnel.

7 December 1995 7 - 8.30 pm

Space, The Medical Challenge

Dr Mike Harrison

Defence Research Agency Centre for Human Sciences, Farnborough

Radiation, vacuum and absence of gravity combine to make space an environment that is overwhelmingly hostile to life. Add confinement and isolation in a fragile habitat, a vulnerable life support system, and the remoteness of help and rescue, and you have the ultimate human challenge - the permanent occupation of space. The talk addresses some of the key medical issues involved in responding to that challenge.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

27 March 1996 10 - 4.30 pm

Call for Papers

Space Transportation

For over a decade the BIS has run symposia on the subject of space transportation. These are intended to provide a forum to cover all aspects of the space infrastructure including the rationale for infrastructure development, system concepts and technology issues. In the past these symposia have been key to the development of HOTOL, Skylon, the Polar Platform and UK thinking on space industrialisation as a part of mankind's future.

Organiser: Mark Hempself

14 - 20 July 1996

Cospar '96 Commission F Assembly

The next biennial assembly of COSPAR, the international Committee for Space Research, will take place in Birmingham. These biennial Commission F conferences (the last was held in Hamburg in 1994), provide one of the most important forums for the discussion of the present status and future directions of space research.

In recognition of the part BIS has played over the past decade in publishing scientific research papers on the relatively new and now rapidly evolving subject of planetary environmental engineering - terraforming - the Society has accepted the invitation of COSPAR to co-sponsor the F3.4 symposium. The organiser of the programme of the symposium *Implanting Life on Mars* is Prof. Robert H. Haynes (President of the Royal Society of Canada) and it is scheduled to be the three hour evening session of the opening day of the conference July 15, 1996.

Fuller details will be published at a later date.

IAF CONGRESS

Benefits of Space for Humanity

The 46th IAF Congress of the International Astronautical Federation will be held in Oslo, Norway, 2-6 October 1995.

Details of the programme are available from the Society. Please enclose a 19p stamp.

LIBRARY

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Buzz Aldrin
Apollo 11 Astronaut
Member of the British Interplanetary
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- or an official Society pin-on lapel badge ☐†
- or a copy of the book by Robert C. Parkinson "Citizens of the Sky" ☐†

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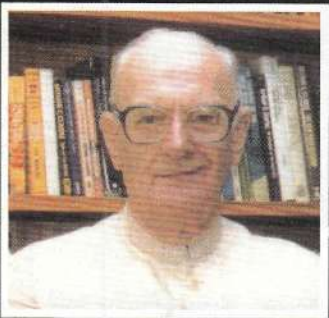
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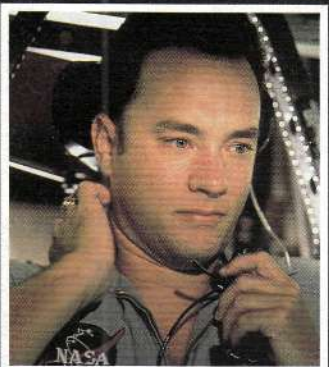


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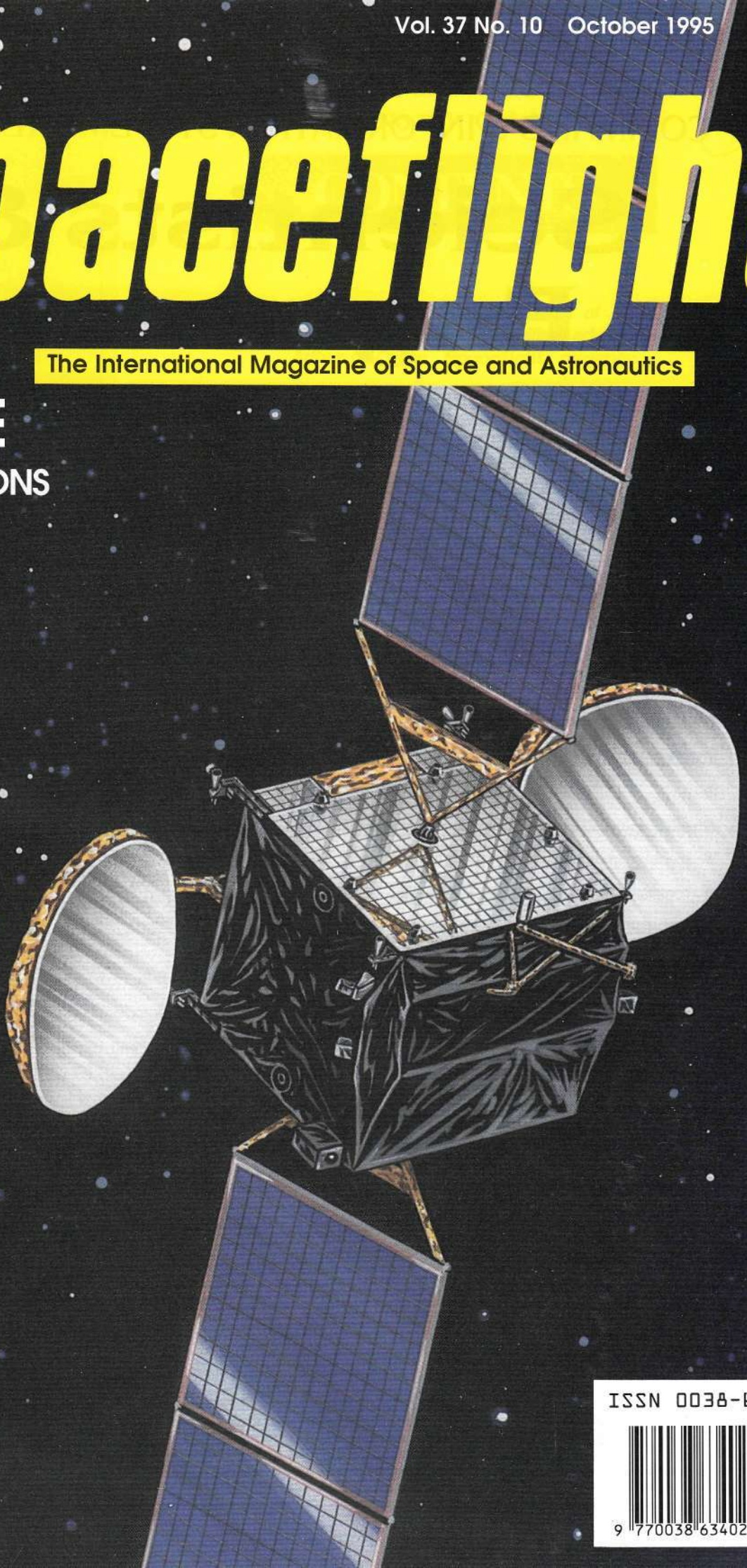
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Film review



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10

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Please contact us for an application form quoting reference CIS/LS/47. CIS Recruitment Liaison Office, Room G107, DRA Malvern, South Site, St Andrews Road, Malvern, Worcs WR14 3PS. Tel: (01684) 895642 (24 hour answer phone) Closing date for receipt of completed applications 20th October 1995.

DRA

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Front Cover: From an artist's rendering of the Astra 1E satellite, the third in a series of spacecraft being built by the Hughes Space and Communications Company for Société Européenne des Satellites (SES) to provide direct-broadcasting services to Europe. With four solar panels on a side, this satellite will deliver 4700 watts of power, allowing coverage of the entire continent. Astra 1E is scheduled for launch in October 1995 aboard an Ariane rocket. It is the next satellite in the Astra constellation and is designed to beam packages of programmes in digital mode. See p.342 for further details by *Theo Pirard*, courtesy of whom the front cover picture is supplied. HUGHES SPACE AND COMMUNICATIONS COMPANY

Space Technology and Applications

Theo Pirard concludes his special report from the Paris Air Show with the latest information on significant developments in Space Technology and Applications. This follows his previous report on 'Space Transportation' which appeared in the September 1995 issue.

Europe Ventures into 21st Century

ESA Director General Jean-Marie Luton described the challenging decisions to be taken at the Ministerial Conference at Toulouse on 18-20 October 1995.

Space Station

In the field of manned space flights and international cooperation, Jean-Marie Luton spoke about the difficulties of obtaining approval for European participation in the International Space Station Alpha. "Four of the 14 Member States [Germany, Italy, France, Belgium] are favouring such participation; the other 10 have not yet decided". The total budget, required from 1996 to 2003, for ESA participation with the Columbus Orbiting Facility (COF) and the Automated Transfer Vehicle (ATV) is \$2.117 billion. However, ESA has only \$1.65 billion for commitments. An extra sum of \$467 million is needed to keep afloat the hopes of Europe participating in the International Space Station Alpha.

Earth Observation

The ESA Division of Earth Observations described its future activities until the year 2005. These will be based on international cooperation and on the economical impact of remote sensing satellites. To be launched in early 1999 is Envisat-1, for which Matra Marconi Space is prime contractor for the polar platform.

ESA and Eumetsat are working together on the development of METOP-1 to be launched in 2001. For the beginning of the next century, ESA is developing Earth observation satellites around five main themes: ice coverage, coastal zones, atmospheric chemistry, agriculture and oceanography.

Three spacecraft are currently being studied by ESA: Earth Explorer 1 for launch in early 2003, Earth Watch 1 in late 2003 and Earth Explorer in late 2005. While Earth Explorer satellites are technological satellites to test new sensors, Earth Watch 1 is oriented to operational aspects. The development of a family of Earth Watch satellites depends on the economical aspects of the observations and on the long-term presence of partners (public

organisations, private companies).

Satellite Navigation

Rene Collette, ESA Director of Telecommunications, announced a joint venture between the European Commission, ESA and the civil aviation organisation Eurocontrol around the European Satellite Navigation (ESN) Action Programme which aims "to enable Europe to take control of satellite navigation services within its air space".

With a budget of some ECU 150 million, the programme will develop technologies, around a European strategy, that will ensure that data from the existing first-generation of Global Navigation Satellite Systems (GNSS-1), comprising the American GPS and the Russian GLONASS, will also be available for civil use on a reliable basis with the requisite precision. In parallel, studies will be conducted in order to make preparations for a second generation satellite-navigation and positioning system (GNSS-2) to be deployed between 2005 and 2020.

In the GNSS-1 phase, ESA's contribution will be EGNOS (European Geostationary Navigation Overlay Service) with a small navigation payload to relay to aircraft, ships and road vehicles the data from the GPS/GLONASS constellations. EGNOS will enable the recipients to determine their actual positions with greater precision than is possible by using the American and Russian navigation systems; civil users of those systems re-



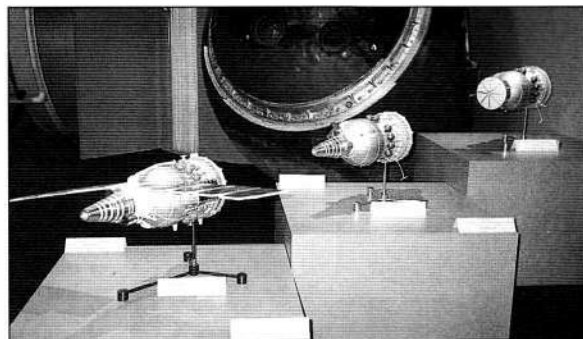
J.-M. Luton, ESA Director General.

ceive artificially degraded data deviating by about 100 m. EGNOS will increase the number of navigation satellites that can be seen by a given user within the geostationary broadcast area. The EGNOS in-orbit infrastructure will consist of transponders in 15-20 kg packages of 200 W to be included in two Inmarsat III satellites, one over the Atlantic East and the other over the Indian Ocean. The development of the EGNOS packages will be funded via the technological ARTES-9 programme of ESA; ESA's contribution will be 100 million ECU, while the remaining 50 million ECU will come from the European Commission.

The surprise in this European venture is the absence of Eutelsat. Rene Collette explained: "The Eutelsat system is dedicated to communications not to navigation signals. In the future, we will be interested to use two or three Eutelsat spacecraft in the geosynchronous arc. For a worldwide system, we will need up to 10 geostationary satellites with navigation payloads."

Seen on the Stands

Right: The Russian fleet of recoverable capsules for Earth observation and microgravity experiments. From left to right: Resurs F-2, Resurs F-1, Foton.



France

French space industry is playing a major role in global satellite communication systems. Four leading companies announced new developments and the status of their current projects.

AEROSPATIALE has signed a \$200 million turnkey development contract for two communications and broadcasting satellites of the Agila system for the Philippines, the Far East and South East of Asia. Agila, using the Spacebus 3000 platform, will carry 38 channels, 26 in C-band and 12 in Ku-band. The first satellite will be delivered in orbit during 1997.

MATRA MARCONI SPACE has won contracts for the direct-to-home broadcasting Hot Bird 2 and 3 satellites of Eutelsat and was preparing the contract for Hot Bird 4. It is the prime contractor for the technological communications satellite Stentor developed by CNES for a launch in 1999. Noël Forgeard, Chairman of Matra Defence Space, announced that Matra Marconi Space would play a role, as the main manufacturer of satellites in Europe, in the establishment of the joint French-German company in the production of spacecraft. Matra Marconi Space is contributing significantly to the development in Europe of satellites for Earth observations.

ALCATEL SPACE is participating in the development of global satellite systems for personal communications (Globalstar) and for digital audio broadcasts (Worldspace). It is cooperating with Space Systems/Loral for the Globalstar system and for the development of the Mabuhay Philippines Satellite Corporation system. In this \$200 million contract, Alcatel Espace will be in charge of the payload consisting of 30 C-band and 8 Ku-band channels.

ALCATEL is looking for financial participation in the Worldspace venture and is discussing cooperation in the development of the global Starsys system using LEO satellites for messaging and location. For the use of LEO satellites, it is studying SATiVoD (Satellite Interactive Video on Demand), a global communications system using low Earth orbit satellites to provide interactive multimedia services. ■

TRW Receives Odyssey Patents

On 8 August 1995, the US Patent and Trademark Office issued TRW a second US patent, covering antenna-pointing features used on its Odyssey satellite-based, worldwide cellular telephone system. The patent covers aspects of Odyssey that enhance telephone service in areas within the "view" of each satellite. It comes three weeks after TRW received a patent that protects Odyssey's Medium Earth Orbit, satellite-based communications system.

SPACEFLIGHT, Vol. 37, October 1995

Brazil

Dr Ajax Barros de Melo, Director General of AEB (Agencia Espacial Brasileira) revealed the budget for AEB's programme would be deblocked at the end of July, giving the green light to major achievements in 1996 with the first test of VLS and with the launch of spacecraft for Earth observations, scientific research and low-cost communications.

The first of the two China-Brazil Earth Resources Satellites CBERS 1 is being prepared for a launch in October 1996; the 1,450 kg remote sensing satellite will be launched by a Chinese Long March 2C and placed in a 778 km circular orbit with an inclination of 98.5 degrees. CBERS-1 with 1 kW power and a two-year design lifetime, will revisit the same area on the globe every 26 days. The multispectral CCD camera will take pictures with 20 m resolution, while the infrared camera will see details of 80 m. The launch of CBERS-2 is planned for late 1998.

SACI, the first Brazilian scientific satellite, will be launched in a piggyback mode with CBERS-1; the 60 kg microsatellite, with 30 W power, includes a payload of 20 kg.

SCD-2, the second satellite for the collection of data, will be launched during 1996; INPE is undertaking its integration and testing. An international RFP of launch services is being issued by AEB. INPE laboratories are being used to test Brazilsat equipment and the Argentinian SAC-B satellite.

The SSR project of Brazilian light satellites for remote sensing missions has been revised to take into account the use of the heavy CBERS spacecraft. The satellite will now be placed in a circular orbit close to the equator to frequently overview the forests in the equatorial region. With the use of multispectral and infrared cameras for vegetation observations, it will complement the mission of the polar orbiting CBERS.

The most ambitious project of Brazil is the creation of the ECCO system that will provide from low orbit wide-area services to equatorial belt countries with voice, data and fax transmission and position location. This LEO comsat system calls for a constellation of 425 kg satellites in 2,000 km circular orbit close to the



An illustration of the China-Brazil Earth Resources Satellite (CBERS-1) in its planned near-polar circular orbit at an altitude of 778 km. INPE

equator; they will cover the countries between latitudes of 15°N and 15°S. Each spacecraft will be made in Brazil and have a 5-year lifetime and a 1,000 channel capacity. Launch of the first ECCO satellite could take place in the second quarter of 1998 in order to have the full constellation operational in 1999. These dates depend on the availability of money to fund this project: ECCO has obtained the go-ahead of the Brazilian government but has not yet received the funding. The satellites will be developed by the public institutions INPE and Telebras, in cooperation with Brazilian and foreign telecom and aerospace industries. American companies will also be involved with the development of ECCO spacecraft: e.g. E-Systems and Aries/Constellation. Brazil is discussing with Indonesia a form of partnership of the ECCO system. The market for ECCO will be some 200,000 handheld terminals in Brazil, a total of 1.6 million handheld terminals in the equatorial countries. ■

LEO and MEO Satellite Communications

Of those active in this work, only Globalstar and Odyssey satellites were on display at the Paris Air Show, being respectively on the stands of Alenia Spazio and TRW.

Right: The Odyssey satellite for the Medium Earth Orbit (MEO) constellation developed by TRW.



Italy

Alenia Spazio is preparing the Italsat F2 communications satellite for a launch planned during Summer 1996. It is the prime contractor of the ESA Artemis satellite to test new techniques in communications; its launch is planned to take place in early 1997.

Alenia Spazio is also participating in the Globalstar system as a shareholder and as a main industrial partner: it is building a new and impressive AIT (Assembly, Integration, Testing) facility at Rome to meet the requirements of the high-rate production of 56 satellites (48 for the orbiting constellation, 8 as back-up) with production to begin during the third quarter of 1996. It is also involved with the development of control systems for the three geosynchronous satellites for the Worldspace system.

The European Commission has selected Alenia Spazio to develop two projects devoted to the introduction of Multimedia services via satellite in Europe. The projects, named ISIS (Interactive Satellite Multimedia Information System) and SECOMS (Satellite EHF Communications for Mobile Multimedia Services) are part of the European programme of research and development, called ACTS (Advanced Communication Technologies & Services). ISIS and SECOMS will require respectively investments of 9.7 million ECU and 13 million ECU; they will test the transmission at 20/30 GHz via the Italsat system. ■

Spain

INTA (Instituto Nacional de Técnica Aeroespacial) is preparing the first launch with the Pegasus rocket in April 1996 of the 201-kg Minisat 01 spacecraft with instruments to study background radiation, microgravity conditions and low-energy gamma radiation.

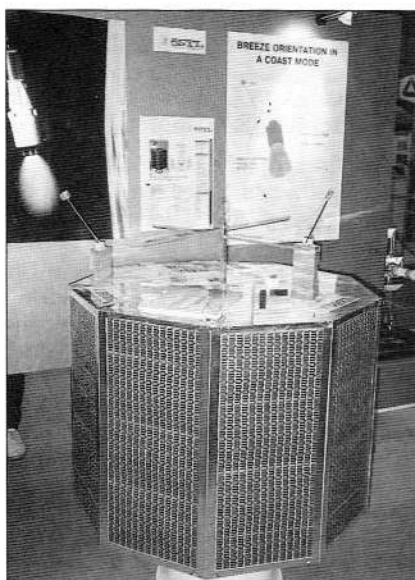
The L-1011 Stargazer of Orbital Sciences will come to Spain in September for final tests and integration. The launch is planned to take place in April 1996 at the latitude of the Canary Islands, where the Maspalomas tracking station is located.

The next step is the preparation of the 550-kg Minisat 1 remote sensing satellite to be launched in 1998. Minisat 1 will use the same platform as Minisat 01; its payload will consist of two telescopes, one for high-resolution images (1-m resolution) and the other for medium-resolution pictures (20-m resolution). This programme will be financed by INTA for 50% (Ministry of Defence) and by the Ministry of Science for 50%, with the support of the Ministries of Transportation, Agriculture and Interior. ■

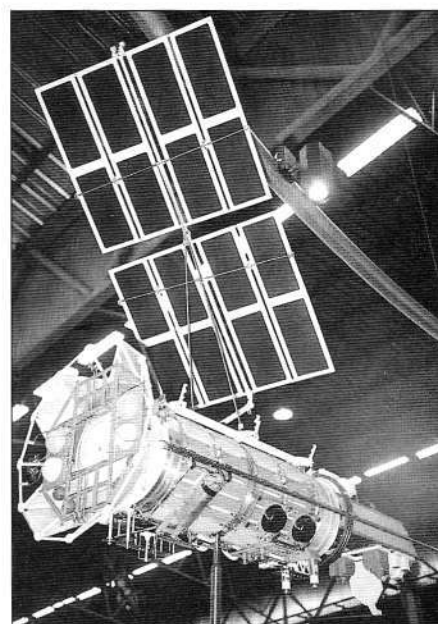
THEO PIRARD

(Photo Credit: Th. Pirard/SIC unless otherwise stated.)

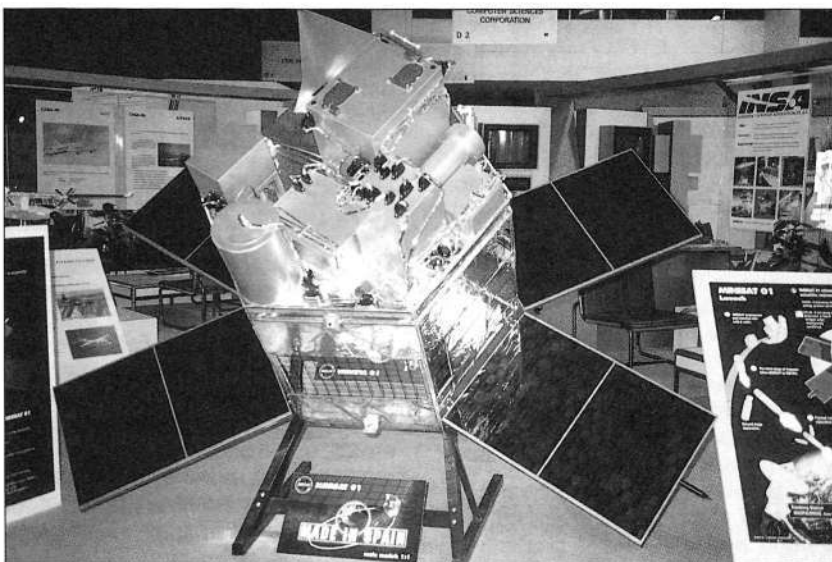
Seen on the Stands



The 200 kg mini-satellite of Surrey Satellite Technology Limited (SSTL) for remote sensing operations which is to be launched in October 1996 on the last three-stage Rocket fired from a Baikonur silo.



The Sitch 1 radar satellite, the first Ukrainian satellite to be used for Earth observations.



Spain's Minisat 01 spacecraft to be used for technological and scientific experiments.

Lavochkin Association, which is a firm specialising in the technology of planetary probes, showed an automated station (left) and a mobile robot (right) which are being developed for MARS '98.



Honours for Satellite Visionary

From World Space Community

British science and science fiction writer Arthur C. Clarke has received the NASA Distinguished Public Service Medal, the highest award that any non-employee of the United States' space agency can receive.

At a special ceremony in London - linking three other locations around the world via satellite - Mr Clarke also joined an elite band of astronauts, cosmonauts and space pioneers in receiving the British Interplanetary Society's Space Achievement Medal.

ARTHUR C. CLARKE is a past President and life-long supporter of the BIS which publishes *Spaceflight* and was founded in 1933 to promote present and future space exploration and technology. The awards marked the 50th anniversary of the first publication of Mr Clarke's revolutionary ideas on how satellites could be used to transmit communications around the world.

Appropriately, the proceedings made full use of today's communication satellites in simultaneous live video links between Sri Lanka, London and two sites on either coast of America. Taking part were the NASA administrator, Daniel S. Goldin (at JPL in Pasadena, California), the Director General of Intelsat, Irving Goldstein (in Washington, DC), Arthur C. Clarke himself (in Colombo, Sri Lanka) and over 200 Society members and special guests in London.

Since the landmark publication of his paper 50 years ago, Mr Clarke, has become one of the most acclaimed science fiction and science authors the world has known.

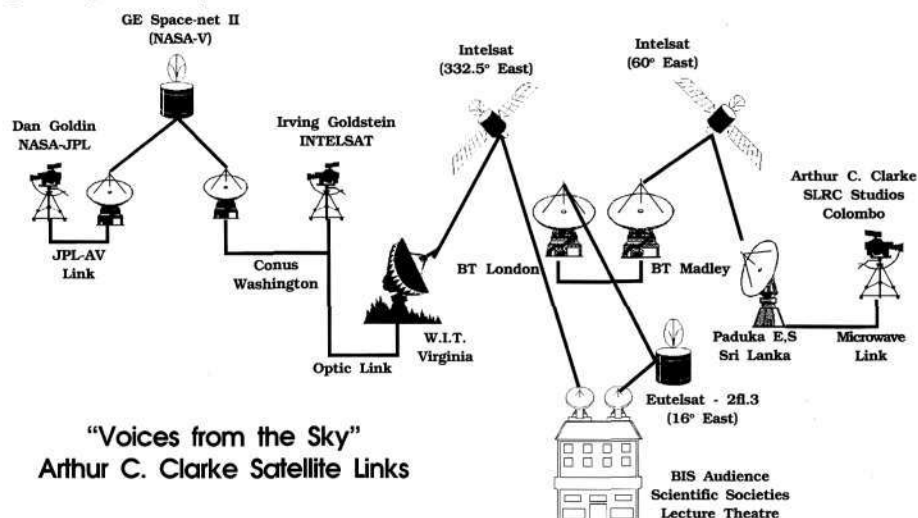
The technology used for the special evening - billed "Voices from the Sky" - included four satellites, seven Earth stations and a variety of terrestrial optical and microwave links.

BIS Executive Secretary, Shirley Jones, said: "We were privileged that so many people wanted to recognise the legacy of Mr Clarke's outstanding work and honour his achievements by their support and the presentation of special awards."

"From a technical point of view alone this was a hugely complex operation to coordinate. Spanning 14 world time zones it really was a very practical demonstra-

tion of how far communications has evolved in five decades".

The NASA Distinguished Public Service Medal was presented by Dan Goldin. The citation on it read: "For your continuing contribution over more than half a century to the exploration and development of space. No writer, living or dead, has done more to demonstrate to the general public the practical value and fu-



• A full report, including Arthur C. Clarke's speech, and tributes by Dan Goldin and Irving Goldstein, will appear in the November issue of *Spaceflight*.

"Voices from the Sky"

What a magnificent idea it was to link the celebration of Arthur Clarke's 1945 concept of the geostationary communications satellite with a teleconference relayed by Intelsat and GE Space-net satellites.

Seated in the Scientific Societies Lecture Theatre in New Burlington Place, London on 18 August, a capacity audience was thus enabled to witness fascinating exchanges between Arthur at his home in Sri Lanka (the man himself appearing on the "big screen" before us) and a number of distinguished guests not just in London but also in the United States.

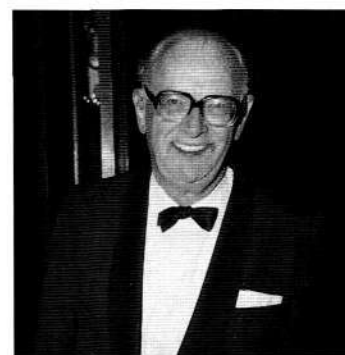
In direct contact with London presenters Dr Paul Thompson, the BIS President, and Professor Garry Hunt, and also appearing directly "on screen", were Dan Goldin, the NASA Administrator participating from JPL, Pasadena, and Irving Goldstein, Director General of Intelsat in Washington, DC.

The evening proved to be a landmark

in BIS history, for what finer tribute could have been paid to this eminent British visionary than that he should communicate using products of his own imagining?

In the mid-Forties Arthur was the rising star of Astronautics who inspired us all and the splendid rewards that were received at this unique ceremony by Fred Clarke on his behalf will stand forever as a tribute to his genius. The sponsors and organisers of this outstanding satellite event deserve our congratulations in full measure. For the record they were BT Communications and ERA Technology; contributing organisers NASA, Intelsat, CONUS and SLRC. And not least the highly competent BIS headquarters staff in London.

KENNETH W. GATLAND



Arthur C. Clarke

ture potential of continued space exploration".

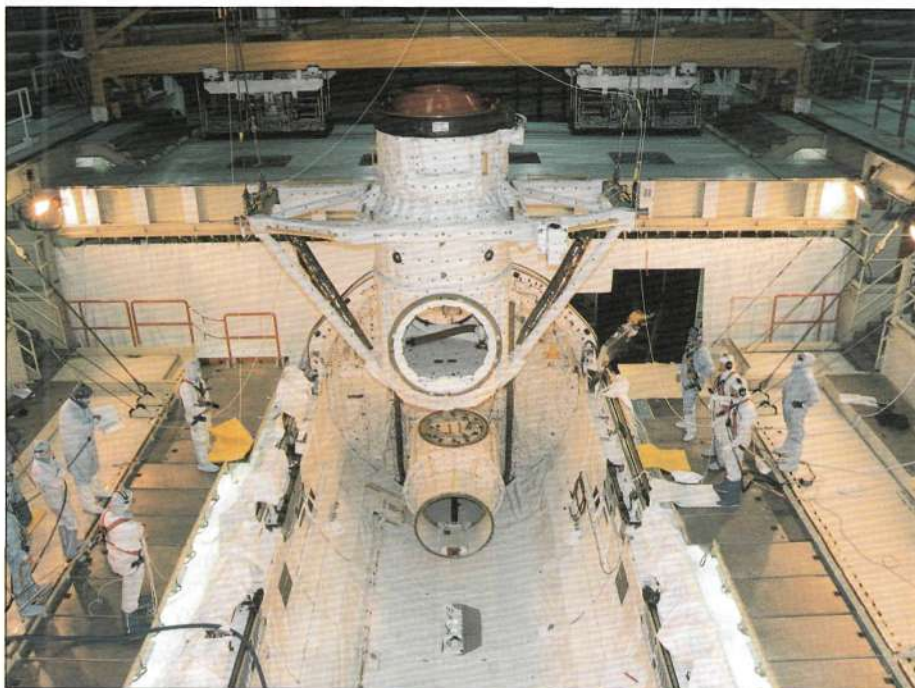
Mr Goldin also revealed that two of Mr Clarke's science fiction works, *Transit of Earth* and *The Sands of Mars*, were being included on a special CD-ROM that would be carried to the surface of Mars by a Russian spacecraft - one of three being launched to study the red planet next year.

Sponsors for the evening were BT Communications and ERA Technology, with support from NASA, Intelsat, CONUS and SLRC. The satellite links were organised by Brian Thomas.

NASA Administrator, Dan Goldin.



Photo: PETER GUALTIERI, WEST KENTUCKY NEWS



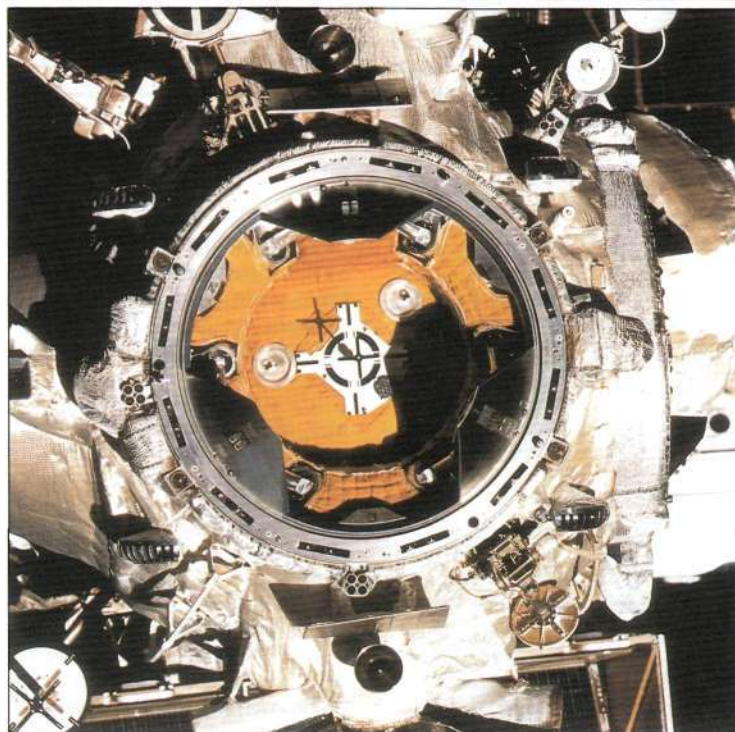
DOCKING SYSTEM

Left: Installation of the Orbiter Docking System (ODS) in the payload bay of Atlantis on 13 March. The ODS is nearly 4.6 m wide, 2 m long, 4.1 m high, and weighs 1,588 kg. It is being installed near the forward end of the orbiter's payload bay and is to be connected by a short tunnel to the existing airlock inside the orbiter's pressurised crew cabin. The Spacelab module, when installed in the payload bay, connects to the ODS via a tunnel. NASA

Below: In the KSC Orbiter Processing Facility high bay 3 on 29 March showing a simulated mating of the Androgynous Peripheral Docking System (APDS) which is part of the ODS with the APDS of Mir. The ODS is seen at the bottom of the photo and is already installed in the Atlantis payload bay. NASA



A video from Atlantis at the moment of docking on 29 June. Atlantis' docking ring is just in view at the bottom of the picture and above it is Mir's Kristall Module. NASA



A video from Atlantis at the moment of docking on 29 June showing the docking target. NASA

Left: The docking target on Mir's Kristall module as it would have appeared to Atlantis Commander "Hoot" Gibson. The photo was taken by the STS-63 crew during their close approach to Mir in February. NASA

First Atlantis Docking Mission

The STS-71 mission was characterised by two historic occurrences. It was the 100th manned space flight launch of the United States' space programme and it would be the first Shuttle to dock with the Russian Mir Space Station.

Orbiter Preparations

In addition to the usual orbiter preparations, Atlantis' mission to rendezvous and dock with the Russian Mir necessitated the installation of a Shuttle-to-Mir Orbiter Docking System (ODS). The ODS was installed on 13 March and successfully completed its test operations in Atlantis' payload bay by 29 March.

The ODS was made up of an external airlock, a supporting truss structure and a Russian docking mechanism and avionics. The docking mechanism contains a compatible latching interface to a docking mechanism on the Mir Kristall module.

The STS-71 Spacelab payload module was installed in Atlantis on 22 March. The Spacelab tunnel, which connects the Spacelab to the Shuttle middeck area and allows the crew access into the Spacelab during the mission, was installed and mated with the Atlantis and Spacelab on 3-4 April.

Atlantis was in the VAB until 26 April, during which time it was mated to its External Tank/Solid Rocket Booster assembly and rollout occurred on 26 April.

Countdown and Launch

The original launch date for STS-71 had been 24 May; however that date had been based on the projected launch of a Russian Spektr module about one month earlier. It had been estimated that it would take about a month to checkout Spektr and then reconfigure Mir for Shuttle docking operations. The Spektr launch was delayed, however, until 10 May and a date of "not earlier than" 19 June was initially picked as the planning date. This was later changed to 23 June.

STS-71 Launch Data

The Space Shuttle Atlantis was launched successfully from the Kennedy Space Center's Launch Complex 39A at 3:32:18.988 pm on Tuesday 27 June 1995. At T plus 123.56 seconds the Solid Rocket Boosters separated from the external tank. Main Engine Cut Off came at launch plus 510.48 seconds. Average vehicle specific impulse for the main engines following SRB separation and up to throttle back was 452.67 seconds of Isp. The launch was a direct insertion launch with an angle of inclination of 51.6°. The primary Transatlantic abort site had been Zaragoza, Spain.

BY ROELOF L. SCHUILING
at the Kennedy Space Center

The countdown began on 20 June with a series of seven built-in-holds. Due to the short launch window of only seven minutes the T-6 hour and T-9 minutes holds were increased by one hour and one half hour respectively from the standard countdown in order to increase the probability of launch. These two increases were also used in the STS-63 Mir rendezvous mission in February of this year.

Final launch preparations went well; however, the weather picture showed only an estimated 20 per cent chance of having good launch weather.

The morning of the 23rd dawned with rain and lightning and so the launch was reset for Saturday 24 June although weather predictions were 70 per cent unfavourable for T-0. The countdown proceeded to T-9 minutes-and-holding and during this time the launch was scrubbed and rescheduled for Tuesday 27 June. The weather predictions did not look favourable on Sunday 25 June or Monday 26 June and the three day delay would allow launch crews to top-off the Atlantis' fuel cell reactant supply.

Due to slightly different orbital parameters on the 27th the launch window would be ten minutes long, lasting until 4:42 pm (all times are KSC times). The launch window for the 27th consisted of two separate but overlapping windows (also referred to as "panes") and supported two mission scenarios. A launch during the first seven minute part of the window would lead to a Mir docking on 29 June, while a launch during the last three minutes would lead to a docking with Mir on 30 June. The earlier docking would lead to a planned landing on 7 July and the later docking would have Atlantis landing on 8 July.

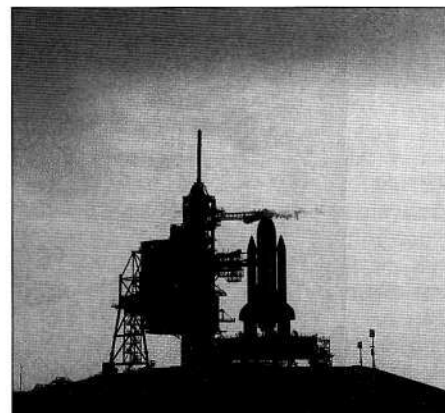
On Monday afternoon the weather prediction for Tuesday held only a 30 per cent chance of being acceptable for launch. Overnight, however the picture improved. June 27 dawned with fog and cloud shrouding the launch site; however these conditions burned off as the Sun rose and the weather predicted for T-0 was only a 40 per cent chance of a weather violation. The final moments before liftoff proceeded as planned and STS-71



STS-71 sits fuelled and ready to go on 24 June as lightning strikes the pad. The vehicle and crew were protected by the lightning arrestor system. (The horizontal line is a video scan line.)

NASA

(Supplied courtesy PETER GUALTIERI,
WEST KENTUCKY NEWS



The weather worsened within minutes on 24 June and thunder triggered a sequence of camera shots of which this is an early one. Later shots barely showed an outline of the launch pad scene.

PETER GUALTIERI, WEST KENTUCKY NEWS

lifted off from Launch Pad 39A a few seconds after 3:32 pm on 27 June 1995. Atlantis' initial orbit was 158 by 85 nautical miles which was the lowest orbit flown by a Space Shuttle. This allowed Atlantis to close the initial 7,000 nautical mile distance to the Mir at a rate of approximately 880 nautical miles per orbit. At about 3 hours forty-five minutes into the flight, Atlantis fired both Orbital Manoeuvring System engines for a burn of about 2 minutes (termed the NC-1 burn) and raised its orbit to 210 by 158 nautical miles.

Mission Day Two

At 6:48 am Mission Commander Hoot Gibson fired the manoeuvring engines for about 14 seconds in the NC-2 phasing burn which placed Atlantis in a 211 by 162 nautical mile orbit closing with the Mir at 250 nautical miles per orbit and precisely aligning Atlantis' ground track with that of Mir. Atlantis had then been trailing Mir by about 3,200 nautical miles. As the crew began their second sleep period in space at 7:32 pm, Atlantis was trailing Mir by 1,330 nautical miles and was in a 216 by 163 nautical miles orbit.

Mission Day Three

The third day of the STS-71 mission saw the historic docking of Atlantis



DEPARTURE

Left: It is launch day, 27 June, and the crew of STS-71 stop and greet photographers before stepping into the Astrovan for the trip to Pad 39A. STS-71 Commander "Hoot" Gibson and Mir-19 Commander Anatoli Y. Solovyev (extreme right) lead the way ahead of their "seconds", STS-71 Pilot Charles Precourt and Mir-19 Flight Engineer Nikolai Budarin. Behind them are STS-71 Mission Specialist Bonnie J. Dunbar and Payload Commander Dr Ellen S. Baker (extreme left). The seventh crew member (not shown) was Mission Specialist Gregory J. Harbaugh.

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A 70 mm camera, carried into space by STS-71 was used to expose this image through a window of the Mir space station to which Atlantis was already docked. The crew cabin of Atlantis is most prominent. Above Gibson's head can be seen the tunnel leading to the Spacelab science module in Atlantis' cargo bay. A port in the tunnel enabled the seven STS-71 crew members to visit Mir and it allowed the three Mir-18 crew members, in space since March of this year, to have access to Spacelab.

NASA



Atlantis rises from its exhaust cloud and rolls to the proper azimuth. This wide-angle shot was taken from a bend in the supply pipes to Pad 39A. A remote NASA camera operated by Bionetics Corporation stands across from the supply pipelines. At one time, the lower pipe used to supply gaseous nitrogen. All pipes no longer carry anything but fibre optic links from Pad 39A to the launch control centre.

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RETURN

NASA Administrator Dan Goldin (far left) talks to STS-71 Mission Commander Robert "Hoot" Gibson (second from left); Pilot Charles Precourt; and Mission Specialists Bonnie Dunbar and Gregory Harbaugh, as Russian Space Agency Director General Yuri Koptev (right) looks on.

NASA



About the Crew

See *Spaceflight*, June 1995, p.186.

with the Mir space station.

Atlantis' seven astronauts awoke at 2:32 am on 29 June and began final preparations for the docking with Mir. Shortly before 4:00 am Atlantis' manoeuvring engines were fired for 45 seconds to raise the perigee of Atlantis' orbit and position the Shuttle about eight miles behind Mir. At about 5:30 am Mission Commander Hoot Gibson fired the engines for the Terminal Initiation phasing burn which began the final part of the rendezvous. The Terminal Initiation burn placed Atlantis in position to intercept Mir from a point directly below the Russian space station on an imaginary line called the "R Bar" or Earth radius vector.

Atlantis stayed at a distance of about 250 feet from Mir while awaiting final approval from Shuttle and Mir mission controllers and then closed to about 30 feet from Mir. At 9:00 am Gibson brought Atlantis into contact with the docking port located on Mir's Kristall module. The two spacecraft were then about 216 nautical miles above the Lake Baikal region of the Russian Federation. Mission Specialist Greg Harbaugh engaged the docking mechanism and locked the two spacecraft together.

After leak checks of the connecting tunnel were completed, the hatches of the two spacecraft were opened and STS-71 Mission Commander Hoot Gibson and Mir-18 Commander Vladimir Dezhurov shook hands in the first American-Russian meeting in space since the Apollo-Soyuz flight 20 years ago.

Following the link-up the Mir-19 crew of Commander Anatoly Solovyev and Flight Engineer Nikolai Budarin officially assumed duties as the Mir crew. The Mir-18 crew moved to Atlantis.

Later, the Spacelab module in Atlantis' payload bay was reactivated by Mission Specialist Bonnie Dunbar in preparation for a variety of medical experiments to be performed during the STS-71 mission. The Atlantis crew, and the Mir-18 crew began their sleep period at about 6:32 pm on Thursday 29 June.

Mission Day Four

During the morning the combined Mir-19, Mir-18, and STS-71 crews met in the Spacelab module for a ceremony commemorating the flight.

STS-71 Main Engines

The Shuttle Atlantis returned to the Kennedy Space Center from California on 22 November and rolled into the Orbiter Processing Facility where its main engines were removed and refurbished engines were installed. STS-71 had main engine 2028 in the upper position; engine 2034 in the lower left; and 2032 in the lower right position. Engine 2032 had flown on STS-66 and was reinstalled after inspections.

Two halves of a pewter medallion bearing the impression of a docked shuttle and Mir were joined together. The Spacelab module was also used to begin medical experiments with the combined crew members.

During the Mir-18 missions, the crew collected a variety of biological samples which, together with cassettes and disks bearing experimental data, were transferred to Atlantis along with experiment equipment. Atlantis also began transferring water by canister to resupply Mir.



Atlantis Commander Gibson and Mir-18 Commander Dezhurov shake hands after the hatches between their two craft have been opened. NASA

Mission Day Five

The crews continued transferring medical samples, equipment and hardware; as well as a broken Salyut-5 computer, from Mir to Atlantis. Equipment was also transferred from Atlantis to Mir, including spacewalking tools which will be used to work on a jammed Mir solar array after Atlantis' departure. Water canisters were again provided to Mir. Thus far about 580 pounds of excess Shuttle water had been transferred to Mir.



Gibson and Dezhurov symbolically join a scale model of the Atlantis-Mir during joint ceremonies in the Spacelab module on 30 June. NASA

Mission Day Six

Medical experiments in the Spacelab module and investigations to understand the orthostatic intolerance sometimes experienced by astronauts upon return to Earth continued. The Mir-18 crew exercised for about one to two hours per day to help adapt to the return to Earth gravity. Thagard and Strekalov also underwent sessions in the lower body negative pressure device.

Transfer and storage of equipment

between the two spacecraft continued, including transfer of excess Atlantis water to Mir. About 860 pounds of water had been transferred using 14 Russian tanks and two Shuttle water bags.

The Mir-19 crew checked out the space suits they would wear during the Shuttle undocking. Plans called for them to undock the Soyuz from Mir and photograph Atlantis as it undocked from Mir about 15 minutes later.

Mission Day Seven

Mir's jammed solar array, located on the Spektr module, was photographed by an electronic still camera aboard Atlantis and the photos were downlinked to assist in refining plans for a later spacewalk to repair the solar array. The array, had failed to deploy correctly when one of the latches used to hold it in place failed to open. EVA repair operations were scheduled to begin about ten days after Atlantis undocked from Mir.

The three crews: Atlantis, Mir-18 and Mir-19 gathered in the Spacelab for an on-orbit joint press conference shortly after 10:00 am. At 1:32 pm the three crews gathered aboard Mir for a farewell ceremony.

At 3:32 pm Mir-19 Commander Solovyev closed the hatch which sealed the Mir-19 crew aboard their space station. Shortly after, at 3:48 pm, mission Specialist Greg Harbaugh sealed the Atlantis hatch after performing a final check of a docking target which would be used by the next Shuttle to visit Mir. Harbaugh then vented air in the connecting tunnel overboard in preparation for the next day's undocking of Atlantis from Mir. The venting, though successful, went slower than expected and mission controllers attributed the effect to thermal blankets partially obstructing the vent.

Mission Day Eight

Aboard Mir, the Mir-19 crew undertook procedures to deactivate the space station's systems in preparation for the crew's entry into the Soyuz spacecraft.

The Mir-19 crew of Commander Anatoly Solovyev Flight Engineer Nikolai Budarin entered their Soyuz and, with Solovyev at the controls, undocked from the Kvant module on Mir at 6:55 am. The Soyuz, which was Soyuz TM-21, had carried the Mir-18 crew to the space station in March. The Soyuz moved back 300 feet to photograph the undocking of Atlantis from Mir.

At 7:10 am Mission Commander Gibson undocked Atlantis by releasing hooks that held the two spacecraft together after which springs built into the docking system gently pushed the two spacecraft apart.

After photographing Atlantis' departure from Mir, the Mir-19 crew aboard



The Mir-18 crew returned from space on the Shuttle as shown in this photo. Laying in special reclining chairs on the Shuttle's middeck during a practice session in Houston are (front to rear) Thagard, Dezhurov and Strekalov. STS-71 mission specialist Bonnie Dunbar is in the standard seat in the background. NASA

their Soyuz redocked with Mir at 7:38 am. The Soyuz redocking with Mir occurred slightly sooner than planned due to a concern with Mir's attitude control computer. As Soyuz was closing back in on Mir the computer automatically shut down. All other systems aboard the space station performed as planned and Russian mission controllers began evaluating the computer.

Atlantis' crew, after photographing the Soyuz docking with Mir, began departing from Mir with a separation firing of the Shuttle's thruster jets. By 3:00 pm Atlantis was about 35 nautical miles from Mir and separating at about 9 nautical miles per orbit.

Mission Day Nine

The primary activities aboard the Shuttle focused on continuing medical and scientific investigations in the Spacelab module. The Mir-18 crew, now in their 113th day on orbit, were the primary test subjects.

Manned Launch Statistics

Prior to the STS-71 launch from the Kennedy Space Center, the United States had launched 2 suborbital and 4 orbital Mercury missions, 10 Gemini, 11 Apollo, 3 Skylab, 1 Apollo-Soyuz and 68 Space Shuttle manned launches. STS-71 would make the 69th Space Shuttle launch and the 100th United States manned space launch. STS-71 was also the 14th mission for Atlantis and the 54th launch from KSC's Launch Complex 39A.

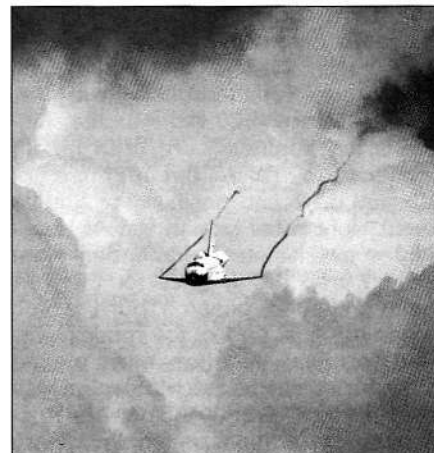
Mission Day Ten

As with other Shuttle missions, this last full day in space was filled with the final checks and preparations for return to Earth. After final medical investigations and exercise sessions by members of the Mir-18 crew, Payload Commander Ellen Baker and Mission Specialist Bonnie Dunbar prepared the Spacelab module for the landing on Friday. Reclining seats were installed in the middeck area for the Mir-18 crew to use during re-entry and landing. The Mir-18 crew would be in their 115th day in space and the seats would allow them to take the re-entry forces in a reclined position.

Mission Day Eleven

The crew closed and secured the airlock connecting the crew cabin to the docking mechanism and the Spacelab module. The Spacelab module was deactivated and seats were reinstalled on the aft flight deck for Mission Specialists Ellen Baker and Greg Harbaugh.

At 9:45 am the braking rockets were fired and Atlantis began its long descent through re-entry and on towards the Kennedy Space Center. Atlantis touched down on runway 15



Atlantis approaches Runway 15 at KSC on 7 July, 10 days after being launched from there and completing a five day docking with Mir. As the shuttle nears, contrails form off the wing tips highlighted here by looming clouds in the background.

PETER GUALTIERI, WEST KENTUCKY NEWS

at 10:54 am on orbit 154 of its 4.1 million mile flight. The main landing gear touched down at 10:55:27 am.

An hour after landing, the Mir-18 crew were brought out of the Shuttle and into the Crew Transport Vehicle for their ride to the crew quarters in the Operations and Checkout Building

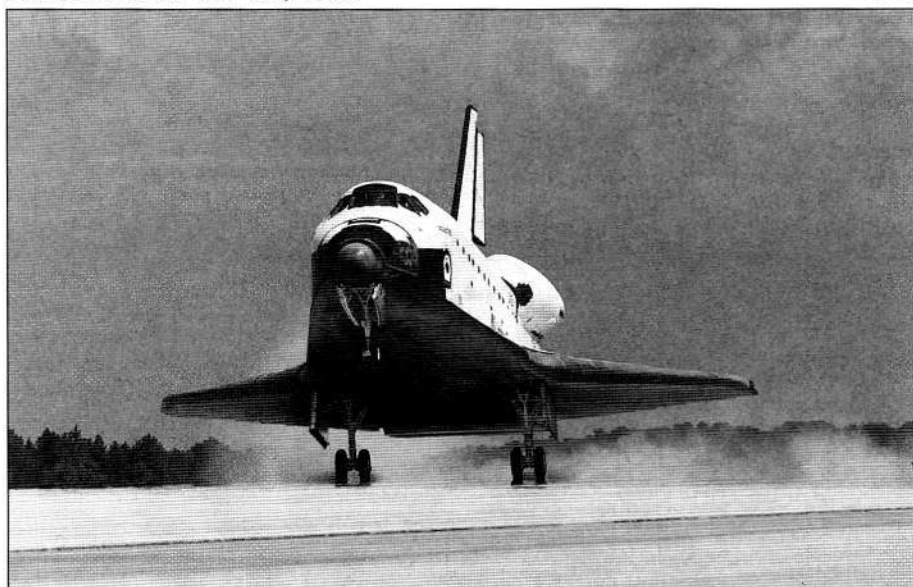
at KSC for initial postflight testing. Later in the day they were flown to the Johnson Space Center for several weeks of further medical checks and readaptation to Earth gravity. Atlantis was towed to the Orbiter Processing Facility where it will be prepared for its next flight, STS-74, which will also feature a rendezvous and docking with Mir. STS-74 is due to launch from Kennedy Space Center on 26 October 1995.

(Grateful acknowledgement is made to Ed Hengeveld courtesy of whom several of the above photos have been supplied.)

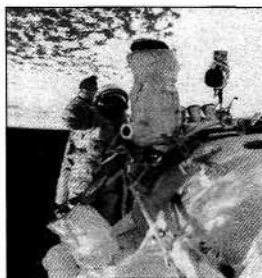


NASA Administrator Dan Goldin and Russian Space Agency Director-General Yuri Koptev field questions from reporters during the post-flight press conference. NASA KSC launch commentator Lisa Malone and Russian translator Vladimir Fischl flank the two top space agency officials. PETER GUALTIERI, WEST KENTUCKY NEWS

Atlantis makes a smooth touchdown on Runway 15 of the Shuttle Landing Facility at 10:54:34 am EDT on 7 July 1995. NASA



Quiz Picture



Readers' responses to the unidentified Mir EVA photo on p.311 of the September issue appear to favour the EVA of 23 January 1991 but opinions are not unanimous:

"The picture shows cosmonaut Viktor Afanasyev undertaking an EVA from Mir on January 23 1991. This was his second EVA of the mission (eighth main expedition to Mir) and he was accompanied outside the station by Musa Manarov. The EVA lasted just over five and a half hours and involved the cosmonauts in a number of tasks including: the setting up of the Strela boom; installation of solar panels; retrieval of material samples and the installation of a spectrometer. This was the 17th EVA undertaken aboard Mir. However . . . I may be wrong!" K.T.W., Scotland

"According to descriptions I have seen in Soviet-released booklets, the EVA shot was of Viktor Afanasyev on January 23, 1991. The EVA saw the installation of the Strela telescopic crane." N.K., England

"I can inform you that the cosmonaut seen making an EVA in the picture was Musa Manarov, on his second visit to the Mir-complex." J.K.A., Denmark

"According to my information the picture shows cosmonaut Alexander Balandin (Soyuz TM-9) in Zvezda's Orlan-DMA space suit waving for the camera during either of the EVAs of 17 or 26 July 1990 and after inspecting a remote-sensing instrument on the Kvant-2 module. For further reference see *Aviation Week & Space Technology*, January 16, 1995. U.R. Switzerland

Our many thanks to those who contributed their opinions.

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SPACELINE

Shuttle Launched After Delays

On 7 September, mission STS-69 finally took to the skies with five astronauts on an 11-day science mission. The launch was seven weeks behind schedule due to booster rocket and electrical repairs. The shuttle will deploy the Spartan space astronomy probe which is being flown for the third time and the Wake Shield Facility for a second time to demonstrate semiconductor crystal growth under super-vacuum conditions.

The crew of Endeavour pose at pad 39A on 19 July, the day before the dress rehearsal of the Terminal Countdown Demonstration Test (TCDDT) for mission STS-69. Left to right: Commander David Walker, Pilot Ken Cockrell and Mission Specialists Mike Gernhardt (a rookie), James Newman and James Voss.

PETER GUALTIERI,
WEST KENTUCKY NEWS



Mir Operations Start for EuroMir 95

The longest mission in European space history of 135 days duration got underway on 3 September with a spectacular blast-off from Baikonur of the Soyuz TM-22 spacecraft carrying ESA astronaut Thomas Reiter and Russian cosmonauts Sergei Avedeev and Yuri Gidzenko.

On 5 September the Soyuz rendezvoused with Mir, first circling it at a distance of 90-120 m before docking under automatic control at the station's forward port. After checking the air tightness of the hatches the Soyuz crew removed

their pressure suits and floated through the hatch into Mir about an hour and a half later. Upcoming operations at Mir include a spacewalk by Reiter on 20 October and a docking of Atlantis on mission STS-74.

ESA's Busy Launch Schedule

Between November 1995 and January 1996, ESA is due to launch an armada of scientific spacecraft to study the Sun, the local space environment and the far reaches of the Universe. Details have already appeared in *Spaceflight*, August 1995, p.268 and September 1995, p.304.

The launch campaign of ESA's Infrared Space Observatory, ISO, will resume at the European launch site at Kourou, French Guiana in early October for a launch on 3 November. Preparations for flight operations by ESOC (the European Space Operations Centre) in Darmstadt, Germany and the flight control centre at Villafranca, near Madrid, Spain are in their final stages.

The SOHO and Cluster missions are ESA/NASA joint missions. SOHO is due to be launched by an Atlas II AS rocket from Cape Canaveral in mid-December. The four Cluster probes will be carried into space by Ariane 5 when it is launched from Kourou on its inaugural flight scheduled for 17 January 1996.

Stranded in Orbit

The first Chilean satellite, FASat-Alfa, was launched on a Ukrainian rocket from the Russian cosmodrome Plesetsk on 31 August. The microsatellite was lifted into orbit attached to a much larger Ukrainian spacecraft called SICH-1 which has been unable to release its passenger.

The satellite was designed and built by the British company SSTL to take pictures of the Earth and the ozone hole above Chile, as well as providing electronic mail communications to universities and schools, and contains highly sophisticated electronics including 23 computers.

"We'll continue to work with the Ukrainians to establish the likely cause of the failure to be sure that we have tried all possibilities to release the stranded spacecraft", said Ed Milton, general manager of SSTL. "As Chile considers its options, talks have started for SSTL to provide a replacement spacecraft, FASat-Bravo, for launch within 6 to 9 months".

Previously, SSTL has successfully launched 11 microsatellites.

Forthcoming Space Shuttle Launches

Mission	Target Date	Orbiter	Duration	Payload(s)	Incl
STS-73	26 September	Columbia	16 Days	USML-2	39
STS-74	26 October	Atlantis	8 Days	Second Mir docking, SAREX	51.6
STS-72	30 November	Endeavour	10 Days	SFU-retrieval, OAST-Flyer	28.5
STS-75	15 February	Columbia	14 Days	Tether Satellite System-1R, USMP-3	28.5
STS-76	21 March	Atlantis	10+1 Days	Third Mir docking	51.6
STS-77	Late April	Endeavour	10 Days	Spacehab-4, TEAMS	28.5
STS-78	Late June	Columbia	14+2 Days	LMS	39
STS-79	August	Atlantis	9+1 Days	Fourth Mir Docking	51.6

Titan IV Booster Setback

The United States Air Force's Titan IV programme scored a pair of impressive successes* in its first two launch attempts of 1995, both missions involving highly-classified payloads for the National Reconnaissance Office (NRO). However, just weeks after the second launch success, a Titan IV second stage rocket nozzle shattered during a late July test-firing at a testing facility in Sacramento, California. The United States' most powerful unmanned launch vehicle was grounded once again, jeopardizing an ambitious programme of missions planned for 1995 and 1996.

The test firing was intended to validate a new thermal material used in an asbestos phenolic ablative skirt of the nozzle of the Titan IV's Stage II rocket engine, manufactured by Aerojet of Sacramento, California. The ablative skirt became too hot, causing the rocket nozzle to break apart at 230 seconds into a 258 second test-firing.

This test failure has delayed a scheduled 20 August 1995 launch from Vandenberg AFB, a Titan IV/No Upper Stage vehicle with another classified national security payload, probably until December 1995. A planned 9 October 1995 launch of a Titan IV/Centaur vehicle, carrying the second Milstar I military communications satellite, has been slipped until 18 November 1995.

The Air Force has ordered the replacement of the "new" rocket nozzles on the Titan IVs at CCAS and Vandenberg, substituting two older-model nozzles with ablative skirts constructed of flight-proven materials.

Once the defective Stage II nozzle has been replaced, the Titan IV/Centaur on Complex 40 at CCAS will undergo a series of tests in preparation for the re-scheduled 18 November launch of the Milstar payload.

* A Titan IV/Centaur lifted off on 14 May from Launch Complex 40 at Cape Canaveral Air Station (CCAS), apparently delivering the first of a new generation of signal intelligence satellites into a geosynchronous orbit, 35,600 km above the Equator. Another Titan IV/Centaur, carrying the latest *Advanced Jumpseat* signal intelligence satellite, was launched on 10 July from Launch Complex 41 into a high inclination trajectory parallel to the US Eastern Seaboard and over the Canadian Maritime Provinces.



The Titan IV/Centaur launch of 10 July 1995 as the vehicle burns through the early-morning haze at Cape Canaveral Air Station. The 20-storey tall Titan, the United States' most powerful unmanned booster, was launched on a high-inclination trajectory. The massive 26.2 m payload fairing shrouded a highly-classified national security payload, most likely an *Advanced Jumpseat* signal intelligence satellite.

ROGER G. GUILLEMETTE

Work on the Titan IV/No Upper Stage vehicle at Vandenberg AFB's Space Launch Complex 4-East (SLC-4E) must wait until the highly-classified payload is removed and placed into storage before access can be allowed to the second stage. This mission will probably not take place until December 1995.

USAF and Lockheed Martin Plan Six Titan IV Launches in 1996

An ambitious schedule of six Titan IV launches is planned for 1996, four from Cape Canaveral and two from Vandenberg, all involving classified

national security payloads for the US Department of Defence (DoD).

- A Titan IV/No Upper Stage launch from Vandenberg, originally planned for January 1996, will undoubtedly be delayed until late First Quarter 1996 at the earliest due to the rocket nozzle problem.
- A Titan IV/Centaur is scheduled to be moved to CCAS Launch Complex 41 on 19 October 1995. It is slated to launch a classified DoD payload on 11 March 1996. This Titan IV is already equipped with the older-model Stage II rocket nozzle and therefore, will not be affected by the current nozzle problem.
- A Titan IV/No Upper Stage vehicle is expected to be transported to CCAS Launch Complex 40 on 12 March 1996 in anticipation of a planned 9 June 1996 launch. This is an unusual launch vehicle configuration for Cape Canaveral and it will also carry a classified DoD payload.
- A Titan IV/Centaur with a classified DoD payload is scheduled for a September 1996 launch from CCAS Launch Complex-41.
- A Titan IV/Inertial Upper Stage vehicle is scheduled for a Fourth Quarter 1996 launch from CCAS Launch Complex 40. The DoD payload is listed as "classified" but this is most likely a Defence Support Program early-warning satellite, DSP F-18. This launch will mark the first test flight of the new Titan IV-B configuration, comprised of the Advanced Solid Rocket Motors (ASRMs) manufactured by Hercules Aerospace, and an advanced ring laser gyroscope guidance and navigation system built by Honeywell.
- A Titan IV/No Upper Stage vehicle with a classified DoD payload is scheduled for a December 1996 launch from SLC-4E at Vandenberg AFB.

ROGER G. GUILLEMETTE

Correction

In the article "Assured Access to Space" on p.271 of the August 1995 issue, the DSP-17 launch of 22 December 1994 (see photo caption) was from Complex 40 (not 41) and the DSP satellite was incorrectly referred to as a classified DoD payload. The launch vehicle was a Titan IV with an Inertial Upper Stage (Titan IV/IUS) and not a Titan IV/Centaur as stated in the introductory paragraph. Our apologies to the author, Roger G. Guillemette.

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Columbia's Microgravity Mission

Following modification and refurbishment at Rockwell International's Palmdale facility in California, the Space Shuttle Columbia's next flight (STS-73) in late September will be another 16-day mission made possible by the inclusion of the unique Extended Duration Orbiter (EDO) system. During the 14-month interval between her last flight (STS-65) and the STS-73 mission, Columbia has undergone thorough inspections of stress and corrosion levels as part of her third post-Challenger Orbiter Maintenance Down Period (OMDP).



The Shuttle Carrier Aircraft is wheeled under Columbia on 7 October 1994 in preparation for its flight on the following day to Palmdale California.

PETER GUALTIERI, WEST KENTUCKY NEWS

Columbia's payload for STS-73 is the Second United States Microgravity Laboratory (USML-2), a collection of materials science, biotechnology, fluid physics and combustion science experiments located within a 23-foot-long European-built Spacelab pressurised module. Several other associated experiments will spill over into the Shuttle's middeck for this complex research flight. In order to operate the large payload around-the-clock, the seven-member crew will be divided into two teams working 12-hour shifts.

The EDO System

The EDO pallet, nicknamed 'the wafer' because it slots into the rear of the payload bay like a silicon chip into a computer, contains additional liquid oxygen and liquid hydrogen reactant tanks for the Shuttle's electricity-generating fuel cells and is the key to long-duration missions. The 15-foot-diameter pallet carries eight tanks - four

Columbia Gets MEDS

The orbiter's interior has changed markedly since STS-65. Now added are the first elements of the new Multifunction Electronic Display System (MEDS), a sophisticated 'glass cockpit' of colour-active matrix liquid-crystal displays and subsystems which replace the outdated Cathode Ray Tube (CRT) flight deck instruments. Eventually, the other three orbiters will also be fitted with the system, following the signing in 1994 of an \$80.58 million contract between NASA and Rockwell's Space Systems Division of Downey, California.

BY BEN EVANS

West Midlands, UK

containing 318 pounds of liquid hydrogen and another four holding 3,124 pounds of liquid oxygen - which provide sufficient electrical power to support the 16-day mission with an average power of up to 22 kilowatts.

In addition to the pallet, several other EDO systems are located throughout the orbiter; most notably the Regenerative Carbon Dioxide Removal System, located in Columbia's nose area in front of the middeck avionics lockers, which uses a similar technique to that employed by the Skylab astronauts in the early 1970s. Cabin air passes over one of two 'beds' every 15 minutes, while the second bed is exposed to the vacuum of space. The heat generated by the collection of carbon dioxide in the 'ac-

About the Crew



A chat with astronaut Albert Sacco, Jr in the Payload Crew Training Complex at the Marshall Space Flight Center on 21 June 1995. He is Professor and Department Head of Chemical Engineering of the Worcester Polytechnic Institute and was back-up payload specialist for USML-1/STS-50.

E. RUDOLF VAN BEEST

The crew is headed by **Ken Bowersox** who, although making his third space flight, is flying for the first time as Mission Commander. His Pilot, **Kent Rominger**, and Spanish-born Mission Specialist **Mike Lopez-Alegria** are both 'rookies', and this trio will serve as the Orbiter crew, performing the bulk of the manoeuvres and general 'housekeeping' of Columbia whilst on-orbit.

The other four astronauts - Payload Commander **Kathy Thornton**, Mission Specialist **Cady Coleman** and Payload Specialists **Albert Sacco** and **Fred Leslie** - are designated as the Science crew and will be responsible for the bulk of research work in the Spacelab module and middeck. However, Spacelab crews 'cross-train' in many areas and consequently the Orbiter crew will play a large part in the scientific research and vice-versa.

Thornton and Coleman, making their fourth and first space flights respectively, were assigned to STS-73 in March 1994, with Sacco and Leslie - both 'rookies' - joining them three months later. Bowersox, Rominger and Lopez-Alegria were named to the crew in November 1994.

tive' bed heats the exposed bed and expels the waste gas into space. More locker space is present on EDO missions, with even the astronauts' sleep stations being employed for stowage purposes when not in use, while an ingenious - though costly - trash compactor is capable of reducing 56 cubic feet of drink cans, teleprinter messages, food containers and other rubbish into a space no larger than 14 cubic feet.

Middeck Experiments

Payloads are located in both the middeck lockers and the Spacelab module. The four payloads in the middeck are:

- The Commercial Generic Bio-processing Apparatus (CGBA);
- Astroculture (ASC);
- Zeolite Crystal Growth (ZCG);
- Middeck Protein Crystal Growth (MPCG).

The CGBA facility, which has flown several times aboard the Shuttle, pro-

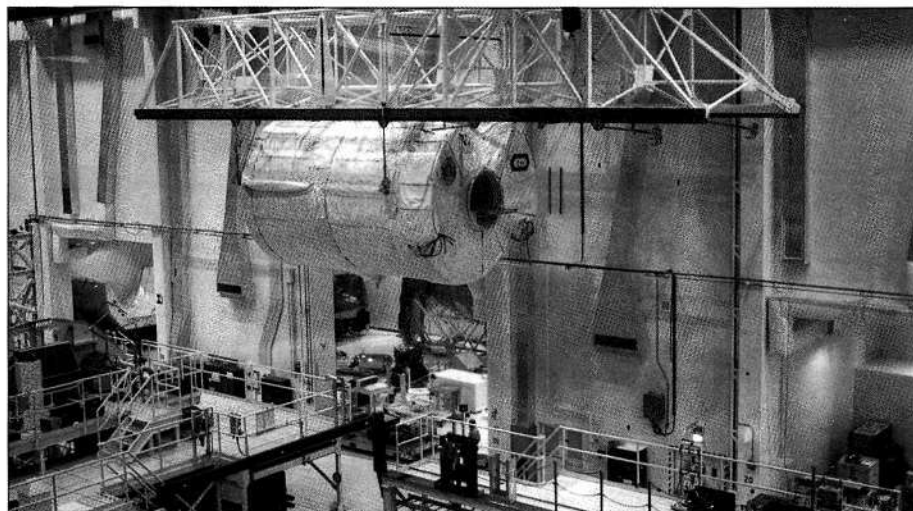
vides a testbed for biotechnological research and uses an eight-chambered Fluid Processing Apparatus (FPA), several of which are organised into Group Activation Packs (GAP).

For USML-2, the CGBA experiments can be classified under three headings, which are:

- Biomedical Testing and Drug Development, which aims to develop a better understanding of how microgravity affects bone metabolism, the immune system and neuromuscular system;
- Ecological Test Systems, which will investigate controlled agricultural applications, waste-management processes and methods of controlling microbes;
- Biomaterials Products and Processes, which will measure the effects of microgravity on bacterial growth, attempt to develop procedures for new pharmaceutical products and delivery systems and study materials which could be employed for the replacement of skin, tendons, blood vessels and corneas.

The ASC apparatus will be making its final flight on USML-2, after which it will become fully-qualified and a functional plant-growth system will be made available for sale or lease to commercial enterprises. ASC contains three main subsystems which address these critical issues necessary for extended space flights. These are:

- A water/nutrient-delivery system utilising porous tubes with different pressures to



In the O&C Building at the Kennedy Space Center on 6 July 1995, the USML-2 is hoisted up from its place in the low bay. It is then loaded into a canister and transferred to the Orbiter Processing Facility (OPF) where it is placed in the cargo bay of Columbia.

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ensure a proper flow through the rooting matrix;

- An efficient system for controlling moisture in the growth chamber which humidifies and dehumidifies the air without the need of a liquid/gas separator;
- A lighting system using light-emitting diodes (LEDs) to provide high levels of light within the limits of the Shuttle's electrical supply.

The ZCG experiment consists of a furnace facility which offers optimum conditions for the growth of large, near-perfect zeolite crystals in the

microgravity environment. Interestingly, the Principal Investigator for the experiment is Albert Sacco, who is assigned as a crew member on USML-2. Zeolite crystals are used extensively in the chemical-process industry as filters, catalysts and absorbents; they also have potential applications as nuclear waste scavengers.

The MPCG experiments are classified under two headings, which are:

- Single-Locker Protein Crystal Growth (SPCG);

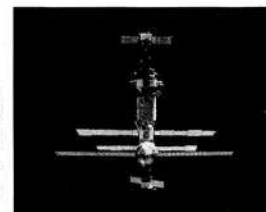
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Mir Rendezvous

STS-63 Mission Highlights Launch Date: 3 February 1995

The 20th orbital flight of Discovery. The crew included as mission specialists Russian Vladimir G. Titov, Janice Voss and British born C. Michael Foale. The prime objective of the mission, and the first stage in the American-Russian space station programme, was to make a close rendezvous with MIR to test the procedures to be used on Mission STS-71 to dock the shuttle with the space station. The video runs for approximately 1 hour and includes some spectacular rendezvous images of the MIR space station.



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Commercial Protein Crystal Growth (CPCG).

SPCG is a single-locker Thermal Enclosure System (TES) unit to effect precise control of conditions for growing small quantities of crystals using the vapour-diffusion method. In the CPCG experiment, samples will be housed in a Commercial Refrigeration Incubation Module and their temperature gradually reduced from 40°C to 22°C over a 24-hour period; the crystals forming as the chamber cools.

Tour of the USML-2 Module

The cylindrical USML-2 Spacelab module is accessed from Columbia's middeck by means of a 19-foot-long pressurised tunnel linking the two. The module is divided into 12 experiment racks - six along each side - into which numerous large payloads are installed. The odd-numbered racks line the port side of the module, with the even-numbered racks along the starboard side.

Racks One and Two, which stand opposite each other at the 'front end' of the module, are designated as the Workbench and Control Centre respectively; the former will be used by the crew to perform general tasks such as the entry of experiment data and also provides a stowage point for equipment and tools, while the latter houses a Payload General Support Computer, an intercom, a High Data Rate Recorder and monitors for the module's environmental and electrical systems.

Rack Three holds the Surface Tension Driven Convection Experiment (STDCE), a payload to investigate basic fluid mechanics and flows of liquid surfaces which are triggered by temperature changes.

Rack Four is reserved for Spacelab subsystems and Rack Five is occupied by the Geophysical Fluid Flow Cell Experiment (GFFC), which will study the motion of fluids in spherical containers in microgravity. Data from this facility will provide a better understanding of fluid flows in oceans, atmospheres and stars.

Racks Six and Eight contain respec-

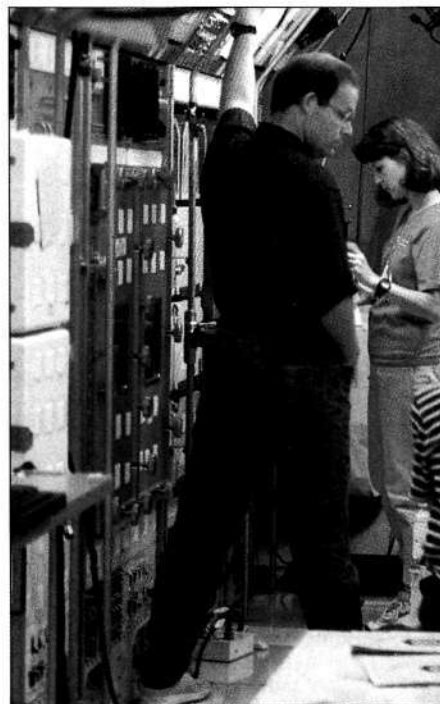
tively the support system and the main experiment facility for the Drop Physics Module (DPM), which will be used to study the dynamics of liquid drops in microgravity and demonstrate techniques necessary for containerless materials-processing.

Racks Seven and Nine will contain respectively the avionics subsystem and main experiment facility for the Crystal Growth Furnace (CGF). This is a furnace facility which will be used to grow semiconducting, metal and alloy crystals by the directional-solidification and vapour-transport methods. For the USML-2 mission, the CGF - which previously flew on USML-1 - has been extensively upgraded to allow data to be gathered at every stage of the processing phase in order to characterise with greater accuracy the point at which crystallisation occurs.

Rack Ten is designated as the Spacelab Middeck Experiments (SMIDEX) rack and will be used to accommodate equipment for the Lower Body Negative Pressure (LBNP), a pressure bag used to pull fluids down into the legs as a countermeasure for the effects of microgravity.

Rack Eleven will hold the Advanced Protein Crystallisation Facility (APCF) which is the first unit capable of conducting three types of crystal growth in microgravity: the liquid-liquid diffusion method (in which protein and salt solutions are separated by a buffer and allowed to mix together slowly when the Shuttle is in orbit); the dialysis method (where the protein and salt solutions are separated by a membrane); and the vapour-diffusion or 'hanging drop' method (in which crystals grow inside a drop of protein solution as solvent from the drop diffuses to a reservoir).

Rack Twelve is reserved for the Glovebox (GBX) facility, a unique system enabling crew members to handle, transfer and manipulate samples in ways that are impractical in the open Spacelab work area. Provided by ESA, it consists of an enclosed cabinet with a large viewing window which offers an uncontaminated workspace and the crew are able to manipulate samples through three openings: two 'glovedoors' and one central port



Kathy Thornton in training in the Payload Crew Training complex at the Marshall Space Flight Center on 21 June 1995. On the left is back-up payload specialist Ray Glynn Holt. The photo is taken in the training module USML.

E. RUDOLF VAN BEEST

though which samples are inserted into the facility. A further development of the GBX facility, known as the Middeck Glovebox (MGBX), is scheduled to make its first flight on the STS-75/Columbia mission in February 1996.

In addition to the experiments in racks aboard the Spacelab module, three further instruments are located on the floor along the centre aisle. These are the Space Acceleration Measurement System (SAMS), the Three-Dimensional Microgravity Accelerometer (3DMA) and the Mission-Peculiar Equipment (MPE) Stowage container. SAMS, which has flown several times on the Shuttle, is an electronic monitor containing three accelerometers to record accelerations and vibrations occurring in the Spacelab module which may have detrimental effects on some of the delicate microgravity experiments. Sensor heads for the instrument are located in two racks (Three and Nine) which contain experiments particularly sensitive to motion disturbances. The 3DMA instrument uses three accelerometers and two sensor heads located in Racks Five and Eight to measure the absolute level of microgravity and the minute accelerations caused by experimental and general onboard activities. Data from the 3DMA instrument may assist researchers in correctly interpreting their experiment results.

Columbia is scheduled for launch from the Kennedy Space Centre (KSC) on 26 September 1995, after which the spacecraft will be inserted into a circular orbit of approximately 150 nautical miles, inclined at 39 degrees to the equator. When the crew are given a 'Go' for orbital operations some 90 minutes later, they will commence activation of the USML-2 experiments.

The fully-prepared interior of USML-2 in the O&C Building at the Kennedy Space Center in June 1995.

E. RUDOLF VAN BEEST



The Snows of Olympus: A Garden on Mars, the illustrated story of man's colonization of Mars

Arthur C. Clarke, Victor Gollancz, Cassel PLC, Stanley House, 3 Fleets Lane, Poole, Dorset, BH15 3AJ, 1994, 120pp, £18.99, ISBN 0-575-05652-5.

This book reviews the exploration of Mars and speculates on the future colonisation of the Red Planet. It is lavishly illustrated with colour pictures from the author's home computer, created by the 3D fractal image generating programme "Vistapro". By using Vistapro to construct images of Martian landscapes and by invoking its facility to 'paint' such a landscape with life, Clarke portrays a virtual reality Mars in the process of being terraformed. The scientific basis of terraforming is briefly mentioned and a reference list of some relevant papers appears in an Appendix.

Astronomies and Cultures

Eds: C.L.N. Ruggles and N.J. Saunders, University Press of Colorado, Distributor: Gazelle Book Services Ltd., Falcon House, Queen Square, Lancaster, LA1 1RN, 1993, 344pp, £35.50, ISBN 0870813196.

Archeoastronomy is a subject which has captured public fascination with its roots in the Stonehenge and "megalithic astronomy" debates of the 1960s and 1970s. Although beginning as a branch of the history of astronomy it has now, together with its sister discipline, ethnoastronomy, been widened to encompass much more.

No longer restricted to the roots of modern astronomy, it now examines how people - throughout history - have perceived celestial objects and integrated them into their views of the Universe, life and daily existence, frequently in ways widely different from those acceptable today.

The book combines this interesting approach to archeology and astronomy proper, with attempts to define and understand the diversity and cultural significance of such contemporary records as have survived the ages. A total of ten contributed chapters illustrate how explanations of ancient artefacts and other records are still evolving and changing towards a tendency leaning more towards "ceremonial" than scientific aspects of the ways in which ancient cultures saw their relationships with the skies. The variety of cultures considered is world-

wide, spanning Hindu, Islam, South America and China.

Practical Astronomy: A User-Friendly Handbook for Sky Watchers

H. Robert Mills, Albion Publishing, Coll House, Westergate Street, Aldingbourne, Chichester, West Sussex, 1994, 235pp, £9.95, ISBN 1-898563-00-4.

This practical manual provides excellent basic material for the non-professional astronomer by assembling a wealth of practical and experimental projects which can easily be conducted at home. The text begins by describing the celestial sphere, following this with the Sun and Sundials before moving on to star maps, planispheres and the like. The next two sections are devoted to light and basic optics, plus a selection of useful miscellaneous information. Measurement and calculation are frequently necessary for a proper understanding of the sky so these, also, are explained and can be easily pursued further with the use of a scientific calculator.

Many of the ideas put forward are original and well presented. The instructions are simple and the illustrations particularly clear.

The Guide to Amateur Astronomy

J. Newton and P. Teece, Cambridge University Press, The Edinburgh Building, Cambridge, CB2 2RU, 1995, 335pp, £24.95, ISBN 0-521-44492-6.

This book, in an easy to use yet comprehensive manner, aims to answer most of the questions posed by both novice and experienced amateur astronomers alike. It tackles such problems as how to choose one's first telescope, or build one from first principles, or even what the deep sky offers in telescopic opportunities, season by season. The emphasis throughout is on practical methods to get started and then moving on to develop skills, using clear text and illustrations to show what is possible.

This is a second edition which has been expanded to feature observational techniques on almost everything from the most basic of visual planetary to CCD imaging of some of the most distant objects in the universe. It also includes a handy review of the colourful new world now available in the form of astro-

Astronomy Selection

software for use on home computers.

RR Lyrae Stars

H.A. Smith, Cambridge University Press, the Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1995, 156pp, £40.00, ISBN 0-521-32180-8.

The closing years of the 19th century saw astronomers subjecting globular star clusters to increasingly close scrutiny, leading to the discovery of the first short-period variable stars today known as RR Lyrae Stars. The ranks of these stars have swelled so much since then that they now outnumber the known members of any other well-defined class of variable star and, directly or indirectly, have contributed to almost every branch of modern astronomy. The name for this type of star derives from the first to be found, a 7th magnitude variable in Lyrae with a period of 0.56 days, discovered around 1899 and which still, surprisingly, remains the brightest-known member of this class.

RR Lyrae Stars are defined as radically pulsating giant A-F class stars with period in the range of 0.2 to 1.2 days and light amplitudes of from 0.02 mag to mag 2. Though not as bright as Cepheid variables, they are luminous giants which can be detected to considerable distances.

The RR Lyrae stars in any given globular cluster show only a small range in mean brightness, which raises the possibility that they may all have about the same absolute magnitude and can so provide an excellent means of determining stellar distances. Of course, a pre-requisite is that the absolute magnitude of RR Lyrae stars must be determined in some fashion before their use as potential distance markers can be fully realised. A long and still unfinished search for this is still underway, for no RR Lyrae star is near enough to have its distance, and thus its absolute magnitude, measured directly by trigonometric parallax, though this may change with an increasing accuracy in parallax determination such as that demonstrated by the Hipparcos satellite.

This comprehensive account of RR Lyrae Stars traces events from their initial discovery a century ago to their present status and explains the multiple value of these stars in helping to solve a range of astrophysical problems.

The author shows how such

stars are used as a means of probing old stellar populations, both in the Milky Way and beyond, and as a testing ground for theories on pulsation and stellar evolution. He stresses the importance of RR Lyrae stars in helping to reach an understanding of the history and scale of the Milky Way and of the nearer extragalactic systems.

Hazards due to Comets & Asteroids

Ed: T. Gehrels, The University of Arizona Press, 1230 N. Park Avenue, Suite 102, Tucson, Arizona 85719-4140, USA, 1995, 1300pp, \$75.00, ISBN 0-8165-1505-0.

Huge craters all over the world, as well as those on the Moon and other planets, attest to bombardment by comets, asteroids and solar system debris over millions of years. One such major impact on the Earth may have brought about the extinction of the dinosaurs while that of 1908, probably a relatively small object which exploded in the atmosphere above the surface of an unpopulated area in Siberia, showed that such events are not confined solely to geologic time.

Even the impact on a city of a relatively small body could be devastating. For example, the Chinese reported that, in 1490, "stones fell like rain in the Ch'ing-Yan District. The larger ones were about 1.5 kg in weight and the smaller ones about 1kg. They struck dead more than 10,000 people. All of the people in the city fled to other places". Even allowing for some exaggeration, it seems clear that the results of relatively small upper atmosphere explosions by a cosmic body could have serious repercussions, though the account lacks descriptions of the undoubted thermal effects and shock-wave which also must have occurred.

All-in-all, this book covers areas of astronomy not previously dealt with in depth and makes for compulsive reading. It comprises over 40 separate contributions, grouped into eight subject areas and brings together no less than 120 contributors to examine the problems of searching for and identifying hazards from comets and asteroids, and of intercepting them to alter their orbits. This last includes possible defences against approaching bodies by applying existing technologies such as rocket boosters, solar sails, nuclear explosives, robotic mass drivers and other propulsion systems. It demonstrates that possible cataclysmic impacts on Earth may be averted with tomorrow's technology.

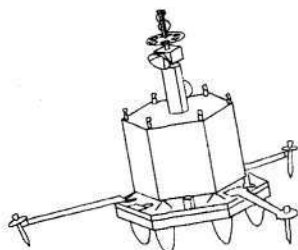
These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

Comet Landing Planned for 2012

The Rosetta comet mission is part of ESA's Horizon 2000 programme of space science (*Spaceflight*, February 1994, p.47). It consists of one Orbiter and two Landers and has now been renamed the International Rosetta Mission after consolidation of international participation involving NASA, CNES and Germany.

The Rosetta Mission Orbiter will carry two Surface Science Packages (SSP's) which will separate from the Orbiter, land on the surface of the Comet P/Wirtanen, and carry out in situ investigations. It is currently planned that one SSP, called Champollion, will be developed jointly by the French Space Agency (CNES) and NASA, and that the second SSP, named RoLand, will be developed by a German consortium.



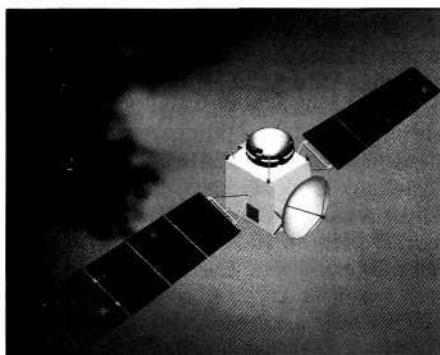
Champollion, the CNES/NASA comet lander.
CNES

The Rosetta mission will be implemented by ESA with the participation of NASA and is being planned for launch aboard an Ariane 5 in January 2003. The orbiter will rendezvous with the comet in August 2011 and carry out remote sensing observations on the comet nucleus until July 2013. In late 2012, the two SSP's will separate from the orbiter, land on the surface of the comet, and carry out experiments in situ.

The complexities and cost of this ambitious mission call for a combined effort by the scientific and technological communities of Europe and the United States. It is currently planned to meet the scientific objectives of the CNES/NASA SSP, Champollion, by a relatively short-lived mission, ending approximately 84 hours after landing on the surface of the comet, while the scientific objectives of the German SSP, RoLand, may be met by a longer-lived mission, possibly lasting up to one year on the cometary surface. Instruments for the Orbiter and SSP payloads will be supplied by the international scientific community.

Artist's illustration of Rosetta.

ESA



Unreliable Comets

BY PATRICK MOORE

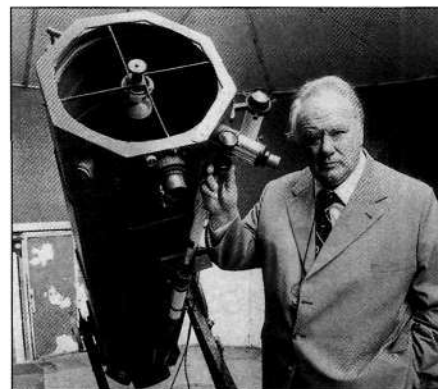
BIS Fellow

We have a new "comet alert". The object discovered by two American amateurs, Alan Hale and Thomas Bopp, is a long way away at the moment - roughly the distance of the orbit of Jupiter - and is well below naked-eye range; but it does show signs of becoming spectacular.

The comet is known officially as C/1995 01, using the new (and, in my view, rather confusing) nomenclature adopted at the last General Assembly of the IAU. The main interest is its brightness. At that distance, it should be far fainter. At the moment the orbit is not known well, because the calculations depend upon a single photograph of the object found in 1993 records, but it does look as though Hale-Bopp is moving in much the same orbit as the Great Comet of 1811, one of the most brilliant on record. Let me stress at once that it is *not* the Great Comet of 1811, which probably has a period of about 3000 years, but it could belong to the same family. And if preliminary calculations are reasonably correct, it should attain almost magnitude -2 in March and April 1997, which is practically as brilliant as Jupiter.

If so, it will cause a great deal of excitement, and the doom-and-gloom eccentrics will be very much to the fore; comets have always caused alarm and despondency! Of course, the chances of Hale-Bopp coming anywhere near us are very slight, and the chances of a collision are infinitesimal; but we must be prepared for a barrage of publicity from astrologers and other cranks, to say nothing of the tabloid press.

Yet can we be sure that Hale-Bopp will become bright at all? Frankly, no. There are two reasons why it may not. First, the presently computed orbit may be wrong, and the comet will be badly placed. (At the return of AD 837 Halley's Comet cast shadows; in 1986 it was obscure.) Secondly, Hale-Bopp may be the wrong sort of comet. It could be a relatively standard object which simply happens to be undergoing a flare at the present time, and it may not go on brightening as it plunges sunward. Do you remember Kohoutek's Comet of 1973? This, like Hale-Bopp, was discovered when a long way away, and seemed to be promising; at one time we were expecting a comet with a maximum magnitude approaching that of the quarter-Moon, and a long tail stretching across the sky. Dire predictions were made, and pamphlets published; it was claimed that the comet was a sign of divine vengeance upon sinful mankind, and that the end of the



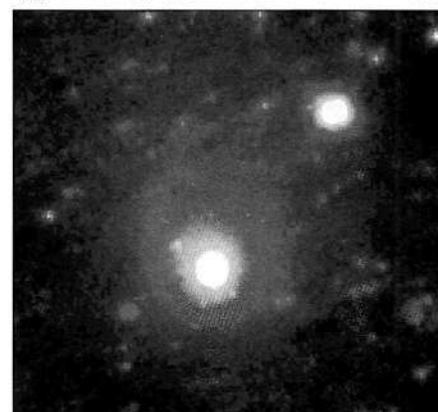
world was nigh. In the event, Kohoutek's Comet was none too easy to see with the naked eye even when at its best.

Comets, like politicians, are unreliable; we never know quite what they will do next, and this certainly applies to Hale-Bopp. All that can be said at the moment is that in the spring of 1997 we *may* have a spectacular visitor - and I hope so, because great comets have been depressingly rare during the 20th century. However, do not bank on it. Hale-Bopp may disappoint us all in the way that Kohoutek did.

May I add a personal note? My first *Sky at Night* programme on BBC television came out in April 1957 and we were ushered in by a comet, Arend-Roland, which although not 'great' was an easy naked-eye object and the best comet for many years. In April 1997 we have our 40th anniversary programme. Will we again be greeted by a comet? Time will tell!

This image of comet Hale-Bopp was obtained by Chris Lidman and Patrice Bouchet on 5 August 1995 with the MPI/ESO 2.2-m telescope at the La Silla observatory during an 8-minute exposure through a filter centred at 1.5 micron wavelength.

The image shows the bright nucleus located in a well resolved dust coma with diameter of about 1 arcminute. The central condensation has a diameter of about 2.5 arcsecond. There is also an approximately 1 arcminute long extension towards the upper right which represents the beginnings of a dust tail, produced by the pressure of sunlight on the dust particles in the coma. The comet's distance from the Sun was approximately 990 million km. ESO



Luxembourg: the Mouse that Roared from GEO!

The Astra Constellation

Prepares for Europe's Step to Digital TV

The small State of the Grand Duchy of Luxembourg is exercising its sovereignty in space up to the geosynchronous circle. By means of its commercial Astra system of broadcasting satellites, this 2,586 km² country - the same size as the county of Dorset, England, or half the size of Delaware State in USA - obtains a larger territory in space than on the Earth!

The technical coordination process of the IFRB (International Frequency Registration Board), within the framework of the ITU (International Telecommunication Union), has authorised Luxembourg to extend its territory to the altitude of 35,800 km, to precisely control spacecraft in a "box" 140 by 70 km at 19.2 degree East and to beam powerful signals from this location into the European continent.

Introduction

Luxembourg's Project - to secure its audio-visual future with the use of direct broadcasting satellites (DBS) for a "Television without frontiers" in Europe - took shape as a national challenge in the late 1970's. DBS frequencies and positions were the subject of a "Geneva Plan" at the 1977 World Administrative Radio Conference. The Luxsat proposal of a high-power satellite, positioned at 19 degree West, was studied by the national broadcaster - and largest taxpayer - CLT (Compagnie Luxembourgeoise de Telediffusion). But this proposal got bogged down under pressure from the French shareholders of CLT. The Luxembourg authorities received a solution from the American side: an ex-Hughes satcoms expert, Clay Whitehead, proposed the GDL concept of a medium-power communications satellite to beam 16 TV channels across Western Europe. Germany and France reacted strongly towards the Luxembourg move opening the way to "Coca-Cola" technology and culture! At the initiative of the Luxembourg government, which

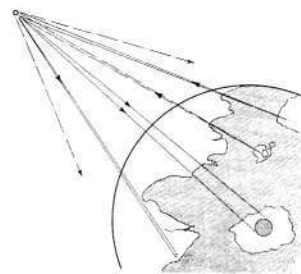
TV and radio broadcasts from the Astra constellation at 19.2 degrees East can be received by a single fixed antenna with Ku-band receiving equipment.

BY THEO PIRARD
Belgium

negotiated the use of geosynchronous locations and frequencies, the private SES (Société Européenne des Satellites) company became a space business reality in Europe.

Technical and Commercial Success

The long-discussed and high-risk venture was incorporated in March 1985 by 11 shareholders which injected LuxFr 337.5 million (some \$12 million). The Grand Duchy holds a 20% interest and some control in SES through two public financial institutions, whilst the rest of the equity capital comes from private international entities. SES can operate a pan-European broadcasting satellite system, at 19.2 degree East, under a franchise agreement with the Grand Duchy. The franchise runs until the year 2010, with the possibility for extension, and covers audio-visual services as well as possible new business applications. The Astra system, owned



This article is dedicated to Arthur C. Clarke on the occasion of the 50th anniversary of the concept of geostationary satellites advanced by him in October 1945.



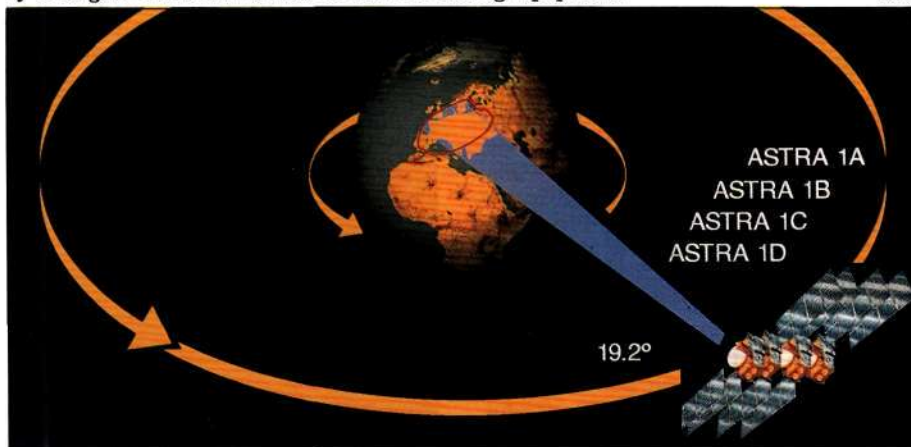
Brazilian Celso Azevedo was Technical Director at SES until June 1995. Before leaving to join Hughes Communications (USA), he announced a promising future for digital broadcasts with the co-located satellites of the Astra system.

by SES, had its first satellite or Astra 1A launched by the first commercial Ariane 4 rocket. SES achieved, within 10 years of existence and five years of Astra operations, some spectacular results.

SES is the first, in the world, to successfully exploit four spacecraft which are co-located on the same geosynchronous position.

At the end of 1994, SES's gross investment amounted to LuxFr 40 billion (100 times the initial capital!) to purchase "made in USA" satellites, to launch them with Ariane 4 vehicles from Kourou and to build the ground segment for accurate and reliable operations in geosynchronous orbit.

The Astra constellation of Ku-band - the spectrum from 10 to 12 GHz - broadcasting satellites is controlled from an impressively modern centre at Betzdorf Castle, some 40 km East of the city of Luxembourg. Its 64-channel broadcasting capacity is able to reach an audience of some 60 million homes, mainly in Germany, the Netherlands and the United Kingdom. This success, against the "de facto" monopoly of the public Eutelsat organisation, was obtained with the policy, open to deregulation, of British Telecom International and of Deutsche Telekom. It significantly contributed to the production and marketing of Direct-To-Home (DTH) receiving equipment throughout Europe. Astra viewers are able to pick up TV and radio programmes directly by installing a fixed satellite dish of 0.60 m in diam-



eter; SES's communication efforts ensure that viewers understand the simplicity of the equipment needed.

SES had been a profit-making and promising enterprise since 1989, the year when the first Astra satellite became operational at 19.2 degree East.

SES's revenues for 1994, with three geosynchronous spacecraft in full service, increased by 32% over the previous year to LuxFr 8.8 billion (\$285 million); this positive development gives earnings at a level of LuxFr 3.9 billion (\$125 million) or at some 10% of the total investment. The revenue from the Astra operations is generated by leasing transponder capacity on the co-located satellites to television and radio broadcasters, who create the programmes. The broadcasters generate their revenue by selling advertising space on their channels or by charging a subscription fee to their viewers. They find the Astra system a very efficient one: the available capacity is fully booked on the four spacecraft at 19.2 degree East. The growing staff of the company numbers 170 people from 15 different nations and cultural backgrounds; this multinational team, with a very young profile - at an average age of 35.5 years - works at the Betzdorf Castle headquarters, at marketing offices in England, Germany, Spain, and at



SES's Satellite Control Facilities close to Betzdorf Castle.

SES

Hughes, Los Angeles. Yves Feltes stated: "This Californian office is justified by the fact that SES is the most important private customer of Hughes outside USA!"

Giant Step to Digital TV

Currently, the services broadcast via the Astra satellites are transmitted using analogue technology. Société Européenne des Satellites plans to place four further powerful satellites at the same location, before mid-1998, to broadcast packages of digital television programmes. This major step represents an additional investment of LuxFr 40 billion (about \$1.35 billion) to acquire three new satellites in orbit and to upgrade the ground infrastructure for the digital (r)evolution in Europe. Through intense activity at Betzdorf Castle, SES is showing high confidence in its future. Located in a nicely rural landscape, the Satellite Technical Facilities needed to control

Extra-Terrestrial Relays

The article by Arthur C. Clarke, published by *Wireless World* in October 1945, makes delightful reading - perhaps even more so today when it can be viewed against the reality of satellite communications. The fact that it mapped out an epoch-making technological development is well recognised and the occasion of the article's 50th anniversary certainly merits special recognition and commemoration.

Nowadays, the title of the article "Extra-terrestrial relays" sounds quaint but it helps to remind us of the 'state of art' of telecommunications in 1945 and so provide a baseline against which to gauge the great step that the article was taking into the future.

The year 1945 had seen the use of rocket propulsion in the form of the V2 and this sets another technological baseline against which to gauge the article's visionary use of the geostationary orbit.

In 1945 it would have been all too easy to have answered 'no' to the question posed by the article's subtitle "Can Rocket Stations Give World-wide



Arthur C. Clarke

Radio Coverage?". In anticipation, the author wrote:

Many may consider the solution proposed in this discussion too far-fetched to be taken very seriously. Such an attitude is unreasonable, as everything envisaged here is a logical extension of developments in the last ten years - in particular the perfection of the long-range rocket of which V2 was the prototype.

Such logical extensions have been made and are continuing to be made and with them new benefits are being brought to more and more areas of human activity. In every aspect, here is food for thought for technologist, educationalist, politician, entrepreneur and everyone else.

many geosynchronous spacecraft, to receive and uplink TV and radio programmes are being enlarged to manage the digital operations with the next

satellites of the Astra constellation. An engineer described the present construction as "the third extension of the facilities: it will boost the Astra system to operate up to 15 antennas of 12 m with up to eight satellites in geostationary orbit, to broadcast, through digital compression, up to 500 TV channels!"

The Betzdorf facilities consist of three interfacing centres in the same glass building:

1. The Satellite Operations Centre (SOC) which constantly analyses subsystem related data transmitted by the spacecraft and sends commands for precise station-keeping manoeuvres to ensure their correct orbital position. A concreted platform

Inside the heart of the Astra system: the Network Operations Centre which monitors the paneuropean broadcasts of the co-located satellites.

SES





The gratitude of SES for British support with the Astra system is shown as Mrs Margaret Thatcher gets a technical explanation about the Direct-To-Home (DTH) receiving terminal for the Astra satellites during her visit to the Betzdorf facilities. SES

launched Eutelsat's Hot Bird 1, the first satellite of a direct-to-home broadcasting system for analogue and digital TV channels. Hot Bird 1, developed by Aerospatiale, was placed close to the Eutelsat II-F1 communications satellite, at 13° East; one month after launch, it was put into operational service with 16 Ku-band transponders of 70 watts output power. The direct-to-home broadcasting satellite of Eutelsat offers transponders of 36 MHz bandwidth, each capable of transmitting the same TV programme in analogue and digital modes. The first four Astra satellites have transponders of 26 MHz bandwidth.

Within the next 30 months, Eutelsat plans to co-locate also at 13° East up to four powerful satellites developed by French industry. Matra Marconi Space has the contract for Hot Bird 2, 3 and 4 to be launched in 1996 and 1997. European viewers of broadcasting satellites could equip the DTH receivers with fixed twin-head antennas in order to collect the signals of both Hot Bird and Astra systems.

SES is not afraid of the competing capacity proposed by Eutelsat. During our recent visit of Betzdorf facilities, Yves Feltes, Press Relations Manager of SES, stated: "There is not a penury of satellite capacity for paneuropean broadcasts, but there is a penury of the best satellite capacity for the broadcasters with attractive packages of TV programmes". Feltes explained

designed for the installation of up to five parabolas of 12 m in diameter is being equipped with two new antennas of TRW for operations of Astra 1F and 1G to be launched in 1996 and 1997.

2. The Network Operations Centre (NOC) which provides a central and monitoring point for the programmes and services transmitted via the Astra system; it coordinates transmissions from more than 22 uplink sites throughout Europe and it continuously monitors the technical parameters related to the television signals and to the performances of every transponder.

3. The Digital Network Operations Centre (DINO) represents the most impressive and challenging expansion, close to the analogue NOC. It will be responsible for the monitoring and the control of the entire Astra digital TV network and for the digital compression of the broadcasts. This compression will allow up to a proposed 10 TV channels per transponder, but an average of 6 high-quality TV channels per transponder, for pay-TV and video-on-demand programmes, will be available.

The Satellite Control Facilities are connected to an autonomous power station that uses gas and diesel generators with full redundancy, to produce a total of 3,600 kW of electricity, as well as the hot water for the cooling equipment of the high-power amplifiers. An SES engineer explained that climatisation is the crucial element to guarantee the non-stop, full-time functioning of the communications with the satellites. The whole equipment was ready for tests in June, in order to be fully operational for the launch, in mid-October, of Astra 1E, the first satellite of the digital broadcasting era. By autumn this year, if everything goes as planned with Ariane 4 launch services, Astra viewers will be able to receive digital services.

Race Between Astra and Hot Bird Systems

The private corporation SES, with up to eight broadcasting satellites co-located at 19.2° East, is not alone in proposing digital broadcasts from space. It is in competition with the public cooperative Eutelsat, a pan-european organisation with 45 member States. On 29 March, an Ariane 4

Launch Schedule for Astra and Hot Bird Satellites.

SES Astra at 19.2° East

11 December 1988: Ariane 4 launch of Astra 1A (GE Astro), with FSS capacity for 16 analogue channels.

3 March 1991: Ariane 4 launch of Astra 1B (GE Astro), with FSS capacity for 16 analogue channels.

12 May 1993: Ariane 4 launch of Astra 1C (Hughes), with FSS capacity for 16 analogue channels.

1 November 1994: Ariane 4 launch of Astra 1D (Hughes), with FSS capacity for 14 analogue channels and BSS transponders (4) for digital broadcasts.

*October 1995: Ariane 4 launch of Astra 1E (Hughes), with BSS transponders (18) for digital broadcasts.

*March 1996: Proton launch of Astra 1F (Hughes), with BSS transponders (18) for digital broadcasts (first commercial flight of ILS-Proton).

* Summer 1997: Proton launch of Astra 1G (Hughes), with BSS transponders (22) for digital broadcasts.

* Early 1998: Ariane or Proton launch of Astra 1H (Hughes).

EUTELSAT Hot Bird at 13° East

30 August 1990: Ariane 4 launch of Eutelsat II-F1 (Aerospatiale), with FSS transponders (16) for analogue broadcasts and communications.

29 March 1995: Ariane 4 launch of Hot Bird 1 (Aerospatiale), with FSS transponders (16) for analogue and digital broadcasts.

* August 1996: Atlas 2AS launch of Hot Bird 2 (Matra Marconi Space), with FSS and BSS transponders (20) for analogue and digital broadcasts.

* Early 1997: Ariane 4 or 5 launch of Hot Bird 3 (Matra Marconi Space), with FSS and BSS transponders (20) for analogue and digital broadcasts.

* Late 1997: Launch of Hot Bird 4 (Matra Marconi Space), with FSS and BSS transponders (20 for analogue and digital broadcasts).

FSS = Fixed Satellite Service (from 10.7-11.7 GHz).

BSS = Broadcasting Satellite Service (from 11.7-12.75 GHz).

the assets and challenges of SES:

1. The Astra system is in advance by employing the available spectrum from 10.7 to 12.7 GHz; it offers 64 analogue TV channels with the first four satellites and it will make available up to 500 digital TV channels with the next four satellites.
2. The capacity of Astra 1E, 1F and 1G to be launched between September 1995 and Spring 1997, is nearly fully booked. French Canal Plus and CLT, German Kirch and Pro 7, and the Dutch group Nethold have revealed their lease of Astra capacity for digital channels. Tests of digital broadcasts, with Astra 1D in the BSS (Broadcasting Satellite Service) frequencies, are underway with British NTL (the former IBA) and BSkyB.
3. Full use of the Ku-band spectrum for TV broadcasts will be made by the constellation of seven Astra satellites at 19.2 degrees East by mid-97; that obliges SES to consider new and complementary possibilities for further expansion to meet the audio-visual needs of the future.

Up to Ten Satellites by Year 2000!

For its next generation of broadcasting satellites, SES is reviewing and studying two types of solutions to expand and upgrade the Astra system:

1. The use of Ka-band frequencies, in the 20-30 GHz bandwidth, opens up new opportunities for broadcasts. Ka-band allows the extensive development of digital compression, the utilisation of smaller antennas (30 cm in diameter), the access to the satellite for video on demand programmes with an uplink antenna of 50 cm to send messages directly to the sat-

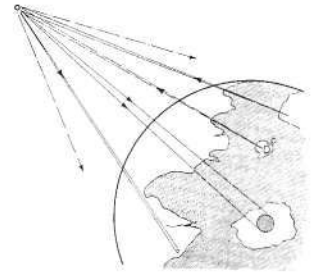
ellite. However, Ka-band is more sensitive to weather conditions and requires the deployment of new receiving systems for the customers. The development of a direct access link from the receiver to the satellite is considered as a long-term effort, requiring technological research during the coming 5 years.

2. The opening of another position on the geosynchronous circle, close to the existing 19.2 degrees East, will allow the deployment a second Astra constellation. This new constellation, employing the present Ku-band and next Ka-band frequencies for analogue and digital broadcasts, will double the broadcasting capacity of the Astra system.

For the next three years, SES is preparing the advent of four spacecraft, which are based like Astra 1C and 1D on the HS-601 platform of Hughes. The cost of each next satellite, including the purchase, the launch, the insurance and the related ground station equipment is in the order of LuxFr 10 billion (\$325 million). The typical timeframe from purchase to delivery is approximately 30 months.

Astra 1E: SES is planning with Arianespace its launch with the 79th Ariane in October. This 5th satellite will make the service of digital broadcasts operational during the fourth quarter of this year.

Astra 1F: SES will launch it with Lockheed-Khrunichev-Energia International on a Proton rocket in March 1996. It will be the first commercial



flight of the Proton with a "made in USA" satellite.

Astra 1G: SES has launch options with Ariane (launch mass: 3,300 kg) and with Proton (launch mass: 2,485 kg).

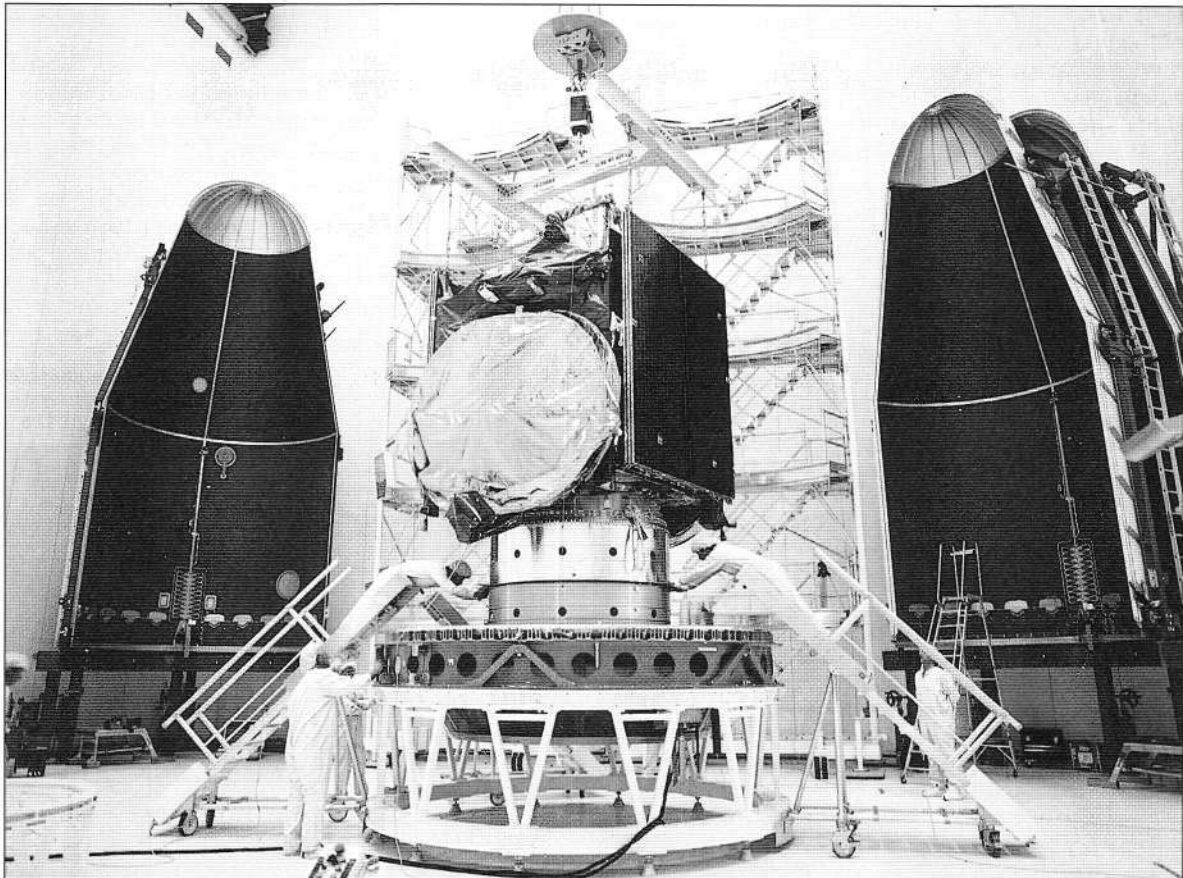
Astra 1H: identical to 1G.

Astra 1H could replace Astra 1A which has been in orbit since 1988 or open a new position for the Astra constellation. SES is confident that Astra 1A, designed for 10-year lifetime, can withstand the space environment for more than 12 years. SES does not exclude the possibility of moving Astra 1A to another position, to use its available transponders for SNG operations and for temporary services required by Astra customers or to upgrade the coverage of countries in the East and in the Middle-East. In July the Board of Directors of SES mandated Management to issue an international RFP (Request for Proposals) for a second generation Astra constellation by the end of this year. ■

(All photos have been supplied by the author.)

Astra 1C being prepared by Hughes technicians at the Guiana Space Centre for its successful launch with the 56th Ariane on 12 May 1993.

ARIANESPACE



Educational Broadcasting

Difficulties in building and maintaining a telecommunications infrastructure across an often extensive and inaccessible terrain have greatly hindered their effective use in many parts of the world. David Parry describes how space technology has helped to overcome these difficulties across the booming Asia-Pacific region and to widen access to education.

Providing the Missing Link

Direct broadcasting by satellite (DBS) is able to relay signals directly to a receiver without the need for a complex array of ground stations. In this way it is possible to cover the remote countryside as easily as urban centres and to bring the wider rural population into the process of education and national development. Significantly and despite the initial expense, satellite broadcasting is proving to be, in the long-term, more cost-effective and reliable than operating a conventional terrestrial system of equivalent speed and capacity.

The first major opportunity to test such a strategy came during the Satellite Instructional Television Experiment (SITE) conducted in India between 1975 and 1976. For a whole year an Applications Technology Satellite (ATS-6) on loan from NASA and described by Arthur C. Clarke as "the most ambitious and important educational experiment in history" broadcast a comprehensive range of domestically produced programmes to over 2,400 villages, each equipped with their own 3 m wide chicken mesh antenna. Surveys later conducted suggested that social problems such as illiteracy were not necessarily a barrier to learning. The imaginative use of visuals and demonstrations aimed at helping to improve various health and farming practices were themselves usually preferred to the more familiar forms of television entertainment [1].

Since the early 1970s satellite broadcasting has proven to be the only practical means of uniting many of the isolated South Pacific islands. In 1971, the Pan Pacific Education and Communications Experiment by Satellite (PEACESAT) set up a radio relay service to link regional educational institutions in American Samoa, Australia, Fiji, the Gilbert Islands, Hawaii, the Hebrides, New Zealand, Papua New Guinea, Tonga and Western Samoa through the use of an earlier US Applications Technology Satellite (ATS-1) based over the equator.

From 1974, the University of the South Pacific began using the system to broadcast its USPNET service, pro-

BY DAVID PARRY
Asia University, Tokyo

viding tutorials for students taking correspondence courses and various information services to the peoples of the region. The current audio-conferencing network organised through the International Telecommunications Satellite Organisation (INTELSAT) has been able to link the main campus in Fiji with the agricultural college in Western Samoa and extension centres in the Cook Islands,

The Global Family

During the last decade, something new has come into the world. Two dimensional communications networks are replacing vertical chains of command, in which orders moved downwards and only acknowledgements went upwards. We are witnessing the rise of the global Family - or Tribe, if you like. Its electronically-linked members will be scattered across the face of the planet, and its loyalties and interests will transcend all the ancient frontiers.

ARTHUR C. CLARKE

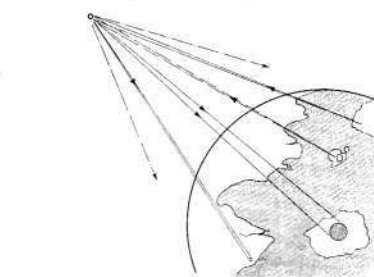
October 1984

(Delivered at a symposium arranged by the Pontifical Academy of Science.)

Kiribati, Nauru, Niue, the Solomon Islands, Tonga, Tuvalu and Vanuatu. The system has met with considerable success. It has been possible to combine and share valuable and often scarce teaching resources throughout the region while reducing the rate of failure among those students studying correspondence courses at home.

Global Classrooms and Remote Teaching

In the late 1970s the US Agency for International Development (USAID) sponsored the Rural Satellite Program, which was designed to assist those countries which already had access to satellite broadcasting. Using Indonesia's own domestic satellite system, PALAPA (Fruit of Effort), and working with Washington State University, an audio conferencing network was cre-



This article is dedicated to Arthur C. Clarke on the occasion of the 50th anniversary of the concept of geostationary satellites advanced by him in October 1945.

ated to link over 10 universities across Indonesia's Eastern Islands and so ameliorate the shortage of faculty staff in such important subjects as soil science.

By the time INTELSAT concluded its Satellites for Health and Rural Education (SHARE) project at the end of 1987, as many as eleven of the twenty individual projects completed had moved on to exploit video-conferencing as an educational medium. As such systems have become ever more cost-effective the idea of a global classroom has become an increasingly realistic possibility. For example, during an experimental video-conference in early 1993, students at Asia University in Japan and Oregon State University in the United States were able to take a class together without either group having to first leave their campus. As such examples of Distance Education become ever more common so the full impact of increasingly cheaper satellite communications may prove to be even more socially and economically revolutionary than the advent of the railway or the development of modern air travel.

The decentralised nature of this communications revolution has however also raised political problems too. In Japan, the notoriously competitive system of university entrance examination has encouraged an increasing number of senior high school students to exploit the increasing availability of extra-curricula satellite classes. Since 1989 the Yoyogi Seminar (a popular Tokyo cram school) has been leasing

In early 1993, a video-conference was held by students at Asia University in Japan and Oregon State University in the US.



Regional Cooperation Under Discussion

The Asia-Pacific Regional Space Agency Forum



The Yoyogi Seminar SATELINE tuition service which broadcasts lectures on a variety of school subjects on a fee paying basis.

capacity on board JCSAT-2 (a private sector communications satellite operated by Japan Satellite Systems Inc.) to distribute its SATELINE tuition service. Lectures in a variety of school subjects have thus been broadcast on a fee paying basis to relatively simple equipment installed in a currently limited number of participating schools throughout the country.

Critics have however expressed concern that such a system can only further inhibit the development of individuality while the purchase of additional lessons from what are essentially commercial organisations has been opposed by both local government authorities and the Ministry of Education as contrary to the universal spirit of public education.

Conclusion

How is the use of satellite communications systems for education and development likely to change in the future?

Following the decision of Indonesia to become the first Asian country to operate a domestic satellite service in 1976, India has made extensive use of its own INSAT system to broadcast various adult education programmes together with supplementary material for classroom use at the primary and secondary school levels. The use of VSATs (very small aperture terminal reception dishes) already familiar to those subscribing to Asia's commercial satellite television channels is set to revolutionise the availability of such equipment in the less developed rural areas of the region thanks to the rising level of mass production.

As the economies of the Asia-Pacific region continue to grow earlier experiments have tended to be followed by more ambitious programmes such as INTELSAT's Project Access (providing free use of spare satellite capacity for social services) which have become

characterised by a more market orientated approach towards the commercial applications of such rural services [2]. An increasing number of Asian countries (for example Thailand, which has been operating the THAICOM system since 1993) have meanwhile acquired their own domestic satellite broadcasting systems as the region continues to invest heavily in modern telecommunications. Despite the familiar rebuff that developing countries can ill afford such technology the question remains: "not whether developing countries can afford the peaceful uses of outer space. Rather it is whether they can afford to ignore them" [3].

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2. The World Bank, Telecommunications and Economic Development, 1994.
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(Photos were taken by the author.)

Meeting of APRSAF-2 held in Tokyo on 31 October and 1 November 1994.

NASDA



Military Satellite Communications in the UK

The history of military satellite communications in the UK for many people started with the Ministry of Defence's SKYNET 1 programme in November 1969. However, much of the technology, design and perhaps more importantly the knowledge and expertise of the people involved can be traced back much further.

Introduction

My own involvement began in 1963 when I joined the Signals Research and Development Establishment (SRDE) near Christchurch, Dorset in the final year of my sandwich degree course in applied physics. The SRDE team that I joined was engaged in developing moon-bounce communications which at that time looked to be a promising military communications system. The team had been looking into Moon-bounce communications since 1959 as had teams in the USA and the Royal Aircraft Establishment at Farnborough. I was immediately fascinated by what then was a new subject and have remained in the business ever since.

What I would now like to do is to trace the history of military satellite communications from the early 1960's to the present time. With hindsight it appears to me that there are three important themes that run through this history. These are:

- (i) Satellites and their orbits,
- (ii) Electronic and microwave technology and
- (iii) The use of spread-spectrum techniques which were pioneered by military satcom researchers.

The Early Years (1960-1969)

Moon Bounce

Prior to my arrival at SRDE in 1963 the team had been building a Moon-bounce system operating at S-band (3 GHz) to investigate the feasibility of using the Moon as a reflector for long distance military communications. At that time skywave HF was the only effective long haul radio communications system available to the military. The main problem to overcome with Moon-bounce was caused by the spherical shape and roughness of the Moon's surface. This produced two main effects, the general smearing out in time over several milliseconds of the reflected signal combined with deep multipath fading caused by the severe roughness (equivalent to tens

of thousands of wavelengths) of the Moon's surface. While it was possible to use fairly conventional (even by 1960's standards!) frequency diversity to overcome the fading it proved more difficult to come up with solutions to the time smearing effects.

In those days there was very little one could buy 'off-the-shelf' and this included the power amplifiers and low noise receivers.

* * *

The Moon-bounce experiments were quite successful but the proposed system suffered from one big disadvantage - the Moon was only visible for 12 hours a day.

* * *

It was during this period between 1964 and 1969 that we at SRDE investigated the possibility of filling the gap in the Moon-bounce coverage with passive reflections from space-junk.

Modern digital signal processing would now offer a complete solution but in the early 1960's such technology was but a dream. We did however manage to build multi-level frequency-shift-keyed analogue systems with literally hundreds of matched filters constructed using painstakingly wound coils on ferrite cores. The resulting filter banks were a nightmare to build, tune up and maintain. Even with the filter banks inside temperature controlled ovens I can remember the feeling of despair at having to do a 'tune up' before each trial.

In those days there was very little one could buy 'off-the-shelf' and this included the power amplifiers and low noise receivers. In the early 1960's the state of the art low noise amplifier was the cavity MASER which used a single crystal of ruby inside a microwave cavity. In order to make the thing work at all it needed to be cooled to liquid

BY R.L. (DICK) HARRIS
Head, Strategic Communications and
Networks Department, DRA

Looking back over the history of military satellite communication it is clear that Arthur C. Clarke's original idea for the geostationary communications relay could not have been more fully exploited in meeting the demands of the military.

helium temperatures. The physics group at SRDE successfully built such a MASER for the Moon bounce work and this must have been one of the first of its kind in Europe. One of my first jobs at SRDE was to look after the MASER which needed routine topping up of its liquid helium bath. The level of liquid helium was critical and if it fell below a certain level the superconducting coil, providing the necessary stable magnetic field, would burn out. The level was almost impossible to see as the refractive index of liquid helium is about the same as the gas. Needless to say my first attempt resulted in complete and utter failure which put the MASER out of action for several weeks. It seemed to me at the time that my career was going to be short and sweet. At least in those days when one had to make everything oneself, one could not avoid getting a superb basic training in a wide range of electronic, electrical and microwave engineering.

The Moon-bounce experiments were quite successful but the proposed system suffered from one big disadvantage - the Moon was only visible for 12 hours a day. According to one visiting VIP of the day, who had better remain nameless, it also suffered from a second disadvantage. He could not be persuaded that the strength of reflected signal did not vary with the phase of the Moon!

Space Junk

Around 1964 we had begun to look for something to fill the gap when the Moon was not around.

By this time artificial Earth satellites were beginning to be launched at an increasing rate. This was at the beginning of what was to become known as the space race between the USA and the Soviet Union. Active communications transponders on these low orbiting satellites were quite rare at the time and of course individual active satellites only gave very intermittent and restrictive coverage. Early Bird and Telstar, in low earth orbits, were then being used for the very first commercial television and telephone experiments. At the time the UK military interest in such things was very luke-

warm. The geostationary orbit was of course known about and Arthur C. Clarke's innovative idea of using it for global communications coverage using geostationary satellites merely a nice idea. Rocket and satellite technology still had some way to go to allow the idea to be exploited.

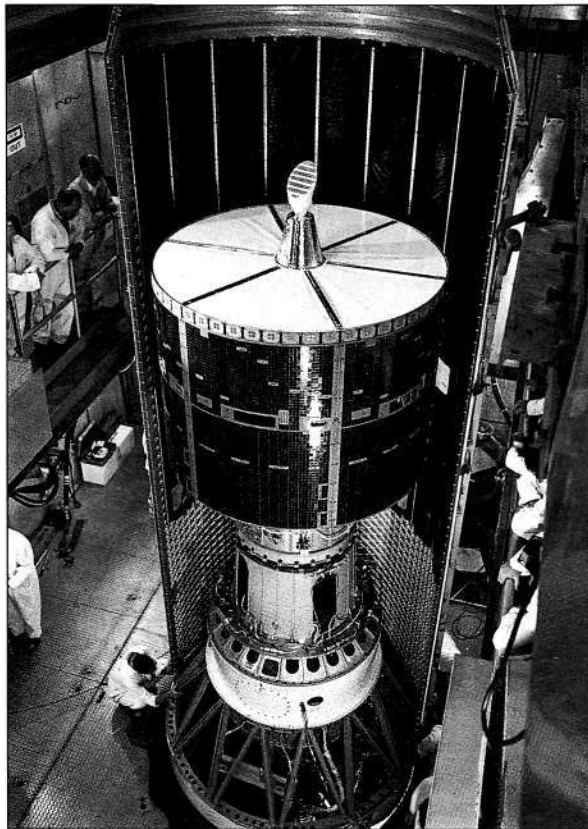
The numbers of satellites, and more importantly the second or third stage rocket bodies in the Earth's orbit were increasing at an amazing rate. We kept track of the numbers in orbit and by the mid 1960's the numbers were still rising exponentially. (Not unexpectedly this trend did not in fact continue and the positive exponential growth flattened out at the end of the sixties.) Just about all of this 'space junk' was in low Earth orbit with orbital periods in the range 90-100 minutes.

It was during this period between 1964 and 1969 that we at SRDE investigated the possibility of filling the gap in the Moon-bounce coverage with passive reflections from space-junk. The most promising objects were the second or third stages of the launch rocket which in most cases achieved a similar orbit to the satellite that they were launching. The main reason for their usefulness as communications reflectors was their large size and hence their large radar cross-section. We had established by 1965 that the size of the reflected signal was large enough for communication links between 10 and 100 kb/s using quite modest sized ground transmitters. These experiments used the large 45 ft diameter 3 GHz tracking radar that was then operating at the Royal Radar Establishment RRE (now DRA) Malvern. The bi-statically reflected signal was picked up on a 17 ft tracking dish at SRDE Christchurch that had previously been used for Moon-bounce. The signals were recorded and analysed for their communications potential. Using this data it was then possible to model the performance of a complete system. This modelling showed that with the 300 or so objects available at that time quite good long term availability at 100s of kb/s would be possible between UK and its bases at places like Cyprus, Gan and Bahrain. At this point the MOD started to show interest and an X-Band parametric receiver was installed at the focus of the RRE S-Band radar behind a di-chroic 'hole' in the centre of the Cassegrain sub-reflector. This allowed a real communications link to be established between an X-band transmitter at SRDE and RRE simultaneously with the radar.

The simultaneous operation of the radar was essential because of the relatively poor accuracy of the tracks of the orbiting junk. The scheme was to use the earlier 'passes' of a par-

ticular piece of junk to update its orbital elements or ephemeris. This was then used to predict the next pass. Even so the prediction accuracy was not good enough for open loop pointing and the error in elevation and azimuth between the actual track as determined by the RRE radar and the predicted track was communicated to SRDE on a teleprinter link. An operator then input these errors manually into the servo loop - a real high technology solution which worked amazingly well!

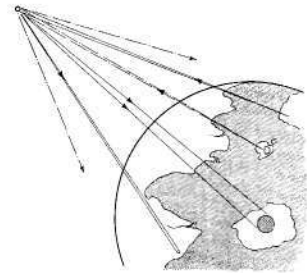
One of my lasting recollections of those space-junk experiments involved the azimuth and elevation predictions which were calculated on an Elliot 803 computer - state of the art for its time. The calculations were so slow that there was only just time to calculate the new output between successive passes of a piece of junk (ie. 90 minutes). I shall never forget the sight of a person, usually the most junior



Skynet IIB being prepared for launch in 1974. DRA/MMS

member of the team, running at full speed clutching a roll of paper tape between the computer room and the aerial field, a distance of some 250 yards, so that the tape could be loaded in time for the next pass. He did not always make it!

One interesting feature of space-junk that was never fully investigated resulted from the cylindrical and cone shaped nature of many of the objects. These particular shapes resulted from the fact that they were of course upper stage rocket bodies and nose cones. While the signals in general exhibited constant-mean Rayleigh fading, because of the small scale irregularities in the objects surface, it



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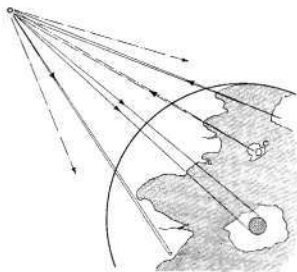
quickly became apparent that many objects exhibited regular 'flashes' in the reflected signal. This occurred when the orientation of the cylinder or cone was such that a specular reflection or 'glint' occurred between the transmitter and receiver. Most objects settled into a stable end-over-end tumble and this meant that the timing of the 'flashes' could be predicted quite accurately. The particular military significance of this was that when such a 'flash' occurred it would only happen along a single position line on the Earth's surface. If one arranged to transmit in bursts synchronised to the 'flashing' then a receiver could only pick up a signal if it were on this position line on the earth. The obvious military advantage was security and anti-jamming.

At this time the US DOD were experimenting with low orbiting communications balloons (ECHO and PAGEOS) to provide large passive reflecting satellites. The idea was that the smooth surface of the balloon would result in a stable non-fading signal. While we were able to use these balloons in our inventory of space-junk they never achieved the smooth stable shapes for which they were designed and the US experiments were discontinued. On one occasion an ECHO balloon collided with its own final stage rocket after one orbit (as was later deduced) resulting in a large cavity being 'pushed' inside the balloon. This caused extremely strange effects on the reflected signals with long unexplained 'tails' appearing on radar inconsistent with the size of the balloon. Many explanations were proposed, including the appearance of extra-terrestrials, before the true cause was established.

IDCSP and the Early SKYNET Era (1966-1976)

IDCSP

In 1966, when we were totally absorbed in our Moon bounce and space junk the USA decided to try and put active communication satellites into geosynchronous orbit. This programme was known as the Initial Defence Communication Satellite Pro-



gramme (IDCSP) and the idea was to fly a large number of very simple, low power single transponder satellites into near-geostationary orbits. To avoid having to station-keep, point or stabilise the satellites they had a near omnidirectional antenna and were placed in an orbit such that they appeared to drift around the Earth every 11 days. The IDCSP satellites were launched up to 8 at a time using a Titan rocket and each was given a slightly different sized push as it left the upper stage of the Titan. This meant that they spread out as they drifted around the earth, the idea being to form an even distribution to give global coverage at all times.

The UK was invited by the USA to join in this programme and consequently the UK MOD decided to build three large 40 ft X-band tracking ground stations using state of the art technology. These terminals became known as SCAT which stands for Satellite Communications Air Transportable Terminals (Yes - air transportable!). The idea was to place them at overseas strategic bases like Hong Kong, Cyprus and Singapore to provide a strategic communications network connecting the far flung outposts of the empire. They had to be air transportable as MOD could not afford to equip every overseas base (we had a lot in those days!). The idea was to move them around to where they were needed most.

Marconi at Chelmsford were chosen to build the SCATs and the three terminals quickly took shape on the old Rivenhall airfield near Witham. The whole project took 18 months from start to finish: time being of the essence. The political imperative was to have at least one terminal operating at SRDE Christchurch in time for the launch of the first cluster of IDCSP satellites. It is to the great credit of the Marconi engineers that this was in fact achieved, although many components were not fully operational when it was delivered.

We at SRDE had been torn away from our beloved Moon and space junk research to set up the SCAT terminal at Christchurch. None of us was very pleased about this disruption to our lives to support what to us seemed a rather silly way to spend a lot of money. While we appreciated the theoretical advantages of Arthur C. Clark's idea for geostationary relay satellites we were not at all convinced that it was worth spending millions of

pounds to achieve data rates of a few kilobits per second! Moreover we were not at all convinced that the active satellites would have any reasonable sort of reliability.

Nevertheless we became involved in commissioning the ground terminals and found that our Moon-bounce and space-junk experience was invaluable in sorting out the many engineering problems that confronted us.

The first IDCSP satellites were duly launched in 1966 and with the exception of a few failures began to operate in their drift orbits. The remaining two SCAT ground terminals were deployed to overseas bases. This established the first UK military satcom system

The first IDCSP satellites were duly launched in 1966 and with the exception of a few failures began to operate in their drift orbits.

* * *

MOD decided to take a step forward and specify a stabilised geostationary satellite with a directional antenna. The system was given the name SKYNET I and the first single transponder satellite SKYNET IA was launched in 1969.

* * *

As can be imagined the two successive disasters on SKYNET IB and IIA tested the resolve of MOD to continue.

which, although only providing a low capacity, nevertheless competed with HF.

The SCAT ground terminals overall reliability improved but the reliability of the cryogenically cooled low noise parametric amplifiers never really got better. It was often the case that the necessary liquid nitrogen supplies ran out, particularly overseas and even at Christchurch. This part of the technology never became reliable until the later development of the varactor diode device technology allowed it to operate with low noise at room temperature. This of course was later superseded by the GaAs FET amplifier which now provides lower receiver system temperatures than were achieved with the earlier cryogenically cooled systems at a fraction of the cost.

SKYNET I

The early successful experience with the IDCSP satellites encouraged MOD to consider further developments. By now it had become apparent that the near geostationary IDCSP concept was not the best solution for a number of reasons. The simple satellites just did not have enough capacity even with large ground terminals. The drift orbit required tracking ground stations, regular hand-overs

and a management overhead in making sure that the two ends of the link were looking at the same satellite! Consequently MOD decided to take a step forward and specify a stabilised geostationary satellite with a directional antenna. The system was given the name SKYNET I and the first single transponder satellite SKYNET IA was launched in 1969 [1]. The satellite was spin stabilised and had a single de-spun Earth cover antenna. At that time there was no indigenous UK industry that was considered capable of designing and building the satellite and a US company Philco-Ford (now part of LORAL after a number of intervening mergers) was selected. However, Marconi Space and Defence Systems (MSDS, now Matra Marconi Space) was deliberately involved in the programme to gain experience. At this time the UK Navy became involved in SKYNET I and the SCOT (Satellite Communications Ocean Transportable) shipborne terminal programme began at ASWE (Admiralty Surface Weapons Establishment) Portsmouth. SKYNET IA was initially a success and indeed was the world's first geostationary military communications satellite, however it suffered premature failure of all its Travelling Wave Tube Amplifiers (TWTAs) after about 18 months of operation.

SKYNET IB was launched in August 1970 but suffered a catastrophic launch failure with the explosion of the solid fuel 'apogee kick' motor inside the satellite. Despite this setback MOD remained committed to a satcom programme and the SKYNET II programme was already well underway.

SKYNET II

The SKYNET II satellites were almost identical to SKYNET I with the exception of the TWT output power which has risen to 20 watts and the Telemetry Tracking and Command System (TT and C) which now operated at S-Band (2-3 GHz) instead of UHF. This change in TT&C operating frequency is in fact the only external way to tell the difference between SKYNET I and II. SKYNET I has long UHF antennas sticking out the back and looking rather like the popular image of a satellite. SKYNET II has instead a ring of S-Band crossed slot dipoles around one of its ends. These were electronically commutated to 'despin' the TT&C beam to keep it pointing at the earth.

By this time MSDS had sufficient experience to take on the responsibility for building SKYNET II satellites and they took on the role of prime contractor, designed and built the communications payload and integrated the complete satellite. The communications payload was similar to SKYNET I in that there were two transponders sharing a single TWT. One of these transponders had a narrow 2 MHz bandwidth to accommodate smaller

tactical terminal accesses like the Royal Navy's SCOT while a wider 20 MHz transponder was used for strategic links using an early form of direct sequence spread-spectrum modem equipment known as the SME (SKYNET Modulation Equipment). The SME operated with a spread bandwidth of 20 MHz (10 Mb/s clock rate) and was one of the first of its type to enter operational service.

Unfortunately SKYNET IIA was another launch failure caused by a malfunction of the third stage of the Thor-Delta launch rocket. Subsequently it was discovered that the servo system steering the gimbals on the third stage went 'hard over'.

The initial reaction of the US launch team was that nothing could have survived such a malfunction and the UK launch team headed home. However, the launch support team was waiting at Los Angeles airport for the flight home when the public address system asked for them to ring the USAF at Sunnyvale (now Onizuka Air Force Base). It turned out that, although the US Air Force had given the spacecraft up for lost, the US Ballistic Missile Early Warning System had naturally logged the launch on its database and tracked SKYNET IIA into a very low elliptical orbit. Contrary to all expert predictions the automatic sequencers on the third stage had not only survived but had worked perfectly and deployed the satellite. SKYNET IIA was now in a very low elliptical orbit with its telemetry enabled waiting for a command from the earth to tell it what to do next. The problem was that the perigee of the orbit was so low that residual air friction would cause the satellite to re-enter the earth's atmosphere and burn up within about 24 hours. Our UK team was asked to go to Sunnyvale to assess the situation and decide whether to command the satellite to fire its remaining solid fuel apogee rocket motor in an attempt to increase the height of the orbit to prevent re-entry. The technical problem was that the orbit was so low that the infra-red Earth sensors were confused and it was not possible to determine which way up the satellite was. This meant that there was a 50:50 chance of the apogee motor causing immediate re-entry! The decision was to fire the motor in order to gain time to assess how well the rest of the satellite and its communications payload was working.

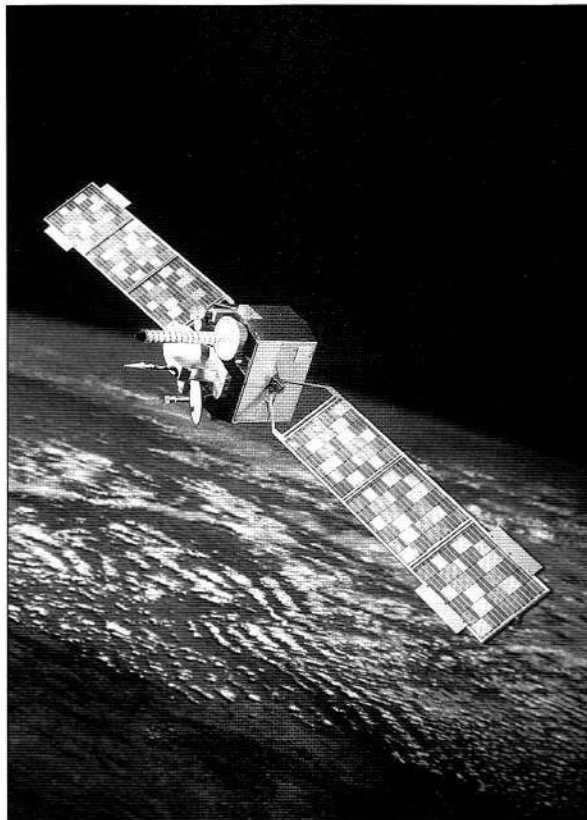
It turned out that the gods were against us and SKYNET IIA re-entered the Earth's atmosphere and burnt up in a spectacular firework display as I recall somewhere over Tibet.

As can be imagined the two successive disasters on SKYNET IB and IIA tested the resolve of MOD to continue.

I have to say that from my own point of view and the SRDE team our suspicions about the inherent reliability of active satellites was being confirmed and our thoughts were turning back to Moon-bounce and space-junk and real science! Nevertheless it was decided by MOD to continue with the launch of SKYNET IIB.

SKYNET IIB was launched successfully on 22 November 1974 [1] and restored everyone's confidence by working perfectly. This satellite marked the beginning of a rapid growth in the use of satellite communications by MOD. In particular the Royal Navy increased the number of ships fitted with SCOT and the Army started the development of what was to become the VSC (Vehicular Satellite Communications) 501 Land-rover based terminal.

Direct-sequence spread-spectrum

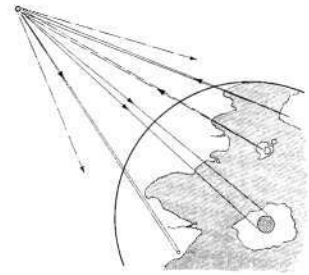


Skynet 4.

MARCONI

was also developed further with the development by SRDE of the Code Division Multiple Access (CDMA) equipment which allowed efficient multiple access by tactical terminals in the narrow 2 MHz bandwidth of the satellite. This equipment built by Marconi is still in operational service with the Royal Navy and Army.

SKYNET IIB continued to function well throughout the 1970's and much to everyone's relief seemed to have reliable TWTA's. Although not used operationally its payload is still functioning today and celebrated its 20th anniversary last year. Possibly the most remarkable fact is that the TWTA, when last measured from DRA Defford in 1994, was still performing to specification after 20 years. This is



even more remarkable when one considers that the cathode in the TWTA had a design life of 5 years! This certainly proves that it is possible to build long lived TWTA's but nobody quite knows what it is that makes it happen!

SKYNET III

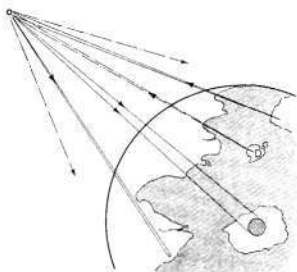
This was the programme that never happened! SKYNET III had been planned as a follow-on to SKYNET II and was to have increased power and improved channelisation. However the major defence review of 1974 with its 'withdrawal from east of Suez' policy resulted in the closure of many overseas bases. SKYNET was seen by MOD at that time as a strategic communication system which connected these overseas bases together. The closure of the bases naturally led to a review of the need for SKYNET. Although the Royal Navy had by then come to rely on satellite communications their requirements were not seen as sufficient to justify SKYNET III. Consequently the decision was made to cancel SKYNET III just as it was entering the first phase of project definition in industry. The Royal Navy's global requirements were to be satisfied on the US DSCS II satellites (the US follow-on to IDCSP) which by then were providing global coverage for the US overseas and CONUS bases. NATO had also by then independently procured its own satellites (NATO I and II) and capacity on them was also negotiated for the UK.

Thus ended the first SKYNET era.

SKYNET 4 (1980-Present)

During the period 1976-1980 the UK's modest satellite communications requirement were satisfied using SKYNET IIB, NATO II and DSCS II satellites. However, the TT and C system on SKYNET IIB failed and although the communications payload continued to function well it became impossible to maintain the satellite in an operational state. This led to increased UK demand for access to the DSCS II constellation which the US were finding increasingly difficult to satisfy.

Against this background new UK requirements for satellite communications were emerging mainly to satisfy Army and Royal Navy tactical operations rather than strategic links be-



tween fixed bases. It was also becoming possible to meet these technically more demanding requirements because of improving satellite ground terminal and modem technology.

At the end of the 1970's NATO had decided to procure a new NATO IV series of satellites and invited national experts to work with the SHAPE (Supreme Headquarters Allied Powers Europe) Technical Centre (STC) to develop a specification and satellite design. Consequently the team at Christchurch (then part of the Royal Signals and Radar Establishment, RSRE) found itself spending much of its time at Scheveningen (near the Hague) as part of a NATO working group developing the concept and design for NATO IV. This was a very enjoyable and productive phase which resulted in an ambitious design (at least for the time) for a three-axis stabilised satellite with four high power wide bandwidth SHF transponders, four antennas (including a high gain spot beam), a special antenna to null out jammers in the Warsaw Pact region and an advanced design of spread-spectrum on-board processing channel for anti-jamming (AJ) operation.

The NATO IV satellite was to support NATO requirements in Europe and the North Atlantic.

However politics entered the scene once more and NATO changed its mind about funding a custom built NATO satellite. Almost coincident with this NATO change in policy the UK policy was moving in the opposite direction towards having its own national system once more.

The increasing demand for UK tactical communications capacity in particular had resulted in the US no longer being able to find enough space capacity on the DSCS II constellation. Consequently in 1980 the UK reversed its policy of 1976 and decided to embark on the SKYNET 4 programme. It was indeed fortuitous that we already had a detailed specification and system level design available from the cancelled SHF NATO IV programme. This, with the addition of the two UHF transponders for submarine communications, needed very little modification to meet the UK requirements for SKYNET 4. After an initial competition between Marconi and British Aerospace (each with a US partner) the contract was jointly awarded with British Aerospace as the prime contractor and Marconi as

the principal sub-contractor responsible for the communications payload.

Originally the SKYNET 4 satellites were to be launched using the US Space Shuttle but shortly before the planned launch of SKYNET 4A the Challenger disaster occurred. Apart from delaying the launch date of the first SKYNET 4 the disaster also changed NASA's launch policy and the UK MOD had to look elsewhere for launch vehicles. To cut a long story short it was decided to launch the first SKYNET using Ariane 4 from Kourou. In order to keep different options open SKYNET 4A was maintained in a shuttle configuration while SKYNET 4B was modified for Ariane launch. Consequently it was SKYNET 4B that was launched first in December 1988 [2] followed by SKYNET 4A a year later. Both launches were very successful and the satellites subse-

Originally the SKYNET 4 satellites were to be launched using the US Space Shuttle but shortly before the planned launch of SKYNET 4A the Challenger disaster occurred.

* * *

... and two, possibly three, replenishment satellites (SKYNET 4D, E and F) are planned for launches starting in 1998.

* * *

Many lessons were learned from the Gulf conflict and these are now being fed into the future requirements and design for the next generation system, SKYNET 5.

quently performed well. A requirement for a third satellite, SKYNET 4C, was later identified and this was duly successfully launched in August 1990.

It had originally been planned to procure a larger number of satellites to cover a longer period. However, due to funding problems the first three SKYNET 4 satellites were procured as a 'Stage 1 programme' with a Stage 2 programme planned as a separate procurement. This indeed is how it has turned out and two, possibly three, replenishment satellites (SKYNET 4D, E and F) are planned for launches starting in 1998. These Stage 2 satellites will be quite similar to those in Stage 1 but do have some improvements to the communications payload including steerable spot beams and higher output power.

It is worth noting that NATO having decided to cancel its own NATO IV programme subsequently bought two SKYNET 4 satellites based on its own original NATO IV specification from the UK MOD. These were designated NATO IVA and B and launched in January 1991 and December 1993.

Recent Years

The SKYNET 4 era has seen a massive expansion in the use of satellite communications by the UK MOD. There has been a steady increase in the types and numbers of ground terminals going into service. The range includes highly tactical man-portable UHF terminals, SHF manpacks, Land-rover based transportable SHF terminals, shipborne SHF (SCOT), UHF submarine terminals and a range of larger transportable and fixed stations in the UK and overseas. Airborne satcoms has been slower to enter service but now this is becoming increasingly important.

In recent years it is probably true to say the Gulf war above all demonstrated the ability of satellite communications to meet the command and control requirements of all three services in out-of-area conflicts. Many lessons were learned from the Gulf conflict and these are now being fed into the future requirements and design for the next generation system - SKYNET 5. This may very well be an international collaboration and will give future military commanders unprecedented access to multi-media information at all levels in the chain of command. The first launch is planned for 2004 with an expected constellation life of 20 years.

Looking back over the history of military satellite communication it is clear that Arthur C. Clarke's original idea for the geostationary communications relay could not have been more fully exploited in meeting the demands of the military. It is difficult to think of another single idea that has underpinned so much innovation, design and technology in the fifty years since its conception.

References

1. "SKYNET Anniversary", *Spaceflight*, June 1994, p.183.
2. Neil Pattie, "Skynet 4 - The Unknown Soldier", *Spaceflight*, May 1989, p.168.

Next Issue . . .

Radarsat

A commercial satellite to make Canada number one in Earth Observation.

Space Shuttle Missions

Recent and upcoming events in the run-up to the second Shuttle-Mir Docking.

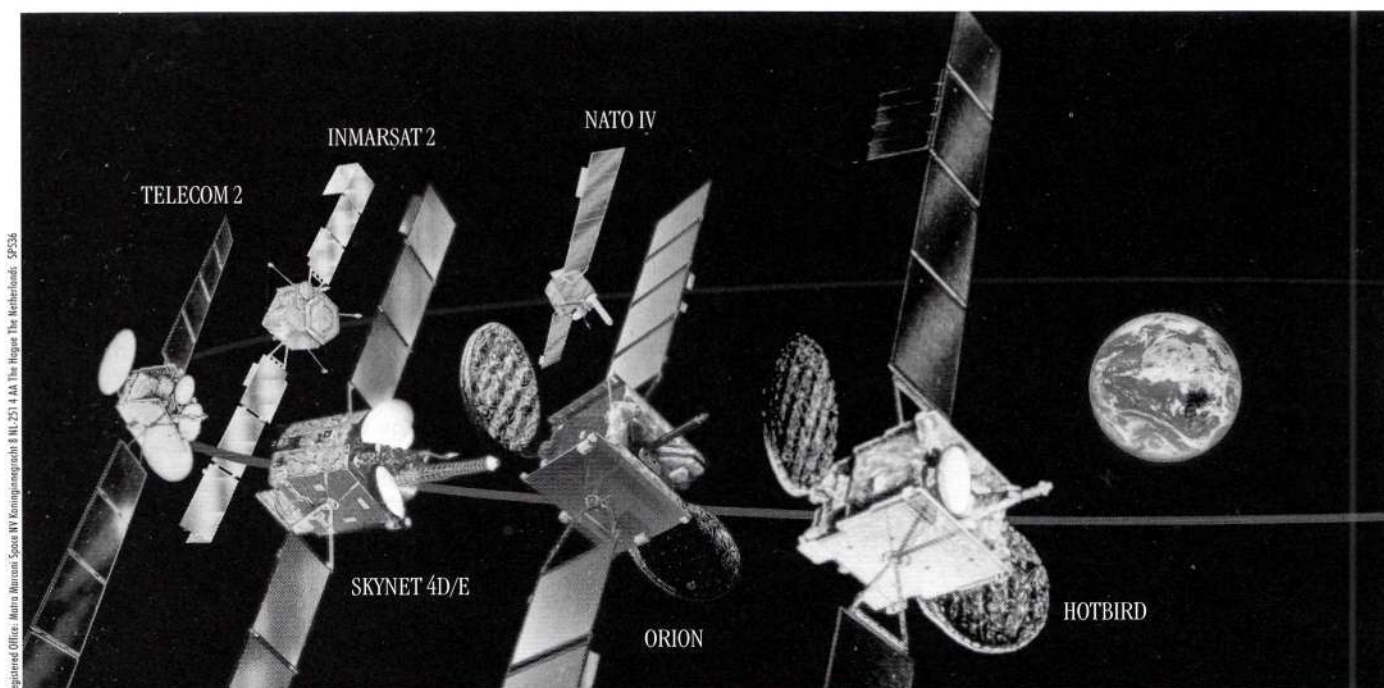
Aboard the Mir Space Station

ESA astronaut puts training experience into practice.

What About Mercury?

What we know about the planet and what we need to find out.

The Clarke Orbit.....50 years on



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Military

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Titan

Sir, Patrick Moore, writing in the August 1995 issue of *Spaceflight*, argues that, if Saturn's largest Moon Titan were to be heated by an ageing Sun to a temperature suitable for human colonisation, its atmosphere would be completely driven off.

But it is worth considering whether the use of advanced technology by our remote descendants might change this conclusion.

In his book *New Earths* (Stackpole, 1981), James Oberg describes how a lunar atmosphere might be created and maintained artificially. He refers to the work of Dandridge Cole and Dr Richard Vondrak; the latter in particular is quoted as stating that a 1-bar oxygen-nitrogen atmosphere on the Moon would take "thousands of years" to drop only 10%. Volatiles for the future lunar atmosphere and hydrosphere would have to be imported; Oberg suggests sending a stolen Saturnian moon (one of the tiny ones - not Titan!) on a "reverse Jupiter swingby".

Given the immense technological powers that our descendants could conceivably wield, and the slow leakage of the lunar atmosphere when considered against a human, rather than an astronomical, timescale, it appears to be perfectly possible that an artificial, Earthlike atmosphere on the Moon could in principle be maintained indefinitely. Nor should we forget that the oxygen component of our own atmosphere on the Earth is maintained entirely by the actions of living creatures.

Since the escape velocity of Titan is nearly 4% greater than that of the Moon, the same possibility would apply even more to Titan if it were to be warmed to an Earthlike temperature.

STEPHEN ASHWORTH, FBIS
Oxford, UK

Patrick Moore writes: I do not quarrel with this, and I agree that at that remote epoch we might be able to do something about it. But at the moment we have no idea how it might be accomplished, so that speculation is endless.

Remember, too, that the Sun's powerful stage will not last for long on the cosmical scale; and when the Sun becomes a white dwarf, Titan will become very chilly indeed!

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Insulting the Free World

Sir, The decision this Summer of the US Patent and Trademark Office to issue a patent which would protect the private and commercial Odyssey system of TRW against competing ventures is astonishing.

From the point of view of a non-US citizen, of an international citizen and of one of the European Union, which I am, I have this urgent question: how can it be acceptable worldwide that a private company, because of a decision in its own country, is able to obtain the exclusive rights to use a particular type of orbit in the sky?

Does this decision consider the international impact and the legal implications for a national administration which undertakes to restrict the use of the space environment which is a freely-available natural resource, open to everybody on Earth?

The patent protecting the Odyssey venture infringes the spirit of the Treaty on Principles governing the activities of States in the exploration and use of Outer Space, Article I:

"Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law."

How then can the federal administration of a pioneering State in the development of free enterprise take the initiative to unilaterally limit the freedom of business in the new world of space, without either consultation or negotiation at an international level? How would the USA react if another influential and powerful

Declassification

Sir, In my article "Lifting the Veil: US-Soviet Competition and Cooperation in Space Prior to Apollo" (*Spaceflight*, August 1995, p.256), I rather recklessly stated that the long time it took to declassify some important documents concerning the American space programme was due to the personal agenda of a NASA official. I should have been far more careful than saying that, and I apologise for my error.

For the record, the only documentation concerning reviews of these documents for declassification dates from 1974 and clearly states that the documents are not NASA exclusive (having been prepared by and with the cooperation of other government agencies) and therefore cannot be declassified by NASA. The documents then sat in a warehouse for two decades totally ignored. Also for the record, NASA, and in particular, its History Division, is incredibly cooperative in the declassification and locating of important documents.

On 17 April 1995, President Clinton signed Executive Order #12958 concerning "Classified National Security Information". This Order is a very significant change in the classification rules for government agencies. It requires all government documents, with only a few very narrow exceptions, to be declassified after 25 years. It also requires the government agencies involved to justify the con-

State decided to take proprietary rights on a specific orbit around the Earth?

The approval, decided by the US Patent and Trademark Office, establishes a first frontier for private advantage in the sky. It has to be considered as a severely restrictive decision for the future of mankind in space - a backward step. It is really insulting the free world.

Is it legal worldwide to allow a private company to lay down the law on a specific trajectory in space? The patent protecting the Odyssey system opens the way to other possible worldwide patents: WHY NOT A PATENT FOR ACCESS TO GEO?

In this situation Arthur C. Clarke would regret that he was not issued with a patent in the United Kingdom or in the State of Sri Lanka for the exclusive use of the geosynchronous orbit: he developed this idea for global communications just 50 years ago. Why did the Soviet Union not protect the 12-hour Molniya orbit for the exclusive use of its communications satellites?

The Luxembourg-based SES corporation is facing competition with the Eutelsat cooperative: so why not look for a patent which will limit, outside the locations of Luxembourg, the co-positioning of more than four broadcasting satellites in the geostationary orbit?

I do not have the exact content and the precise limits of the patent issue, but I cannot stay silent about such a national decision which concerns the whole planet and which protects a private advantage in space.

THEO PIRARD
Space Information Center
Pepinster, Belgium

tinued classification of a document beyond this time limit - a significant change in the rules which now shifts the burden of proof that declassification would be harmful to national security on to the shoulders of the person making the claim. Government agencies were given six months to respond to this Order and explain what actions they were taking to enact it. The Order will officially go into effect in October 1995.

While this substantial change in the declassification rules should make many historians and researchers very happy, there are problems. Foremost among these is the issue of resources. Declassification tasks usually fall on agency historians and/or dedicated declassification offices. These are inevitably overburdened and understaffed. It is not clear if significantly greater resources will be allocated to those who will be responsible for taking on the massive influx of new work. As you are probably aware, the federal government is currently undergoing substantial downsizing and budget cuts and history and declassification offices have never been a priority and may also suffer cuts. Unfortunately, those within the government who are dedicated to assisting historians and researchers may simply not have the resources, despite the change. We can only hope for the best.

DWAYNE A. DAY
Virginia, USA

STS-71 Credit Due

Sir, While we discuss the details and nit-picking of the Shuttle-Mir docking mission, STS-71, let us not forget the big picture and give credit where it is due. How about:

- The people who planned, prepared, practiced and then performed the mission, an exceedingly complex one with options and variables right until liftoff. It went smooth because thousands of people did their job with consummate professionalism.
- Norm Thagard, an extraordinary human being whose personality traits fitted him to the distinct stresses of this project. The fact that he was available for the assignment at the right time was sheer luck - our good luck.
- The medical folk who were told to throw together a programme that made the flight look scientifically valuable - the docking was decreed to occur for political purposes - and who then went and did exactly that, including the agony of the Spektr sideshow and the crew-swap idea that was just crazy enough to turn out to be an excellent idea. We will get the best space biomed data in twenty years, better than the Russian experience and measurements too.
- The enthusiastic public, on Internet and elsewhere, who showed that imagination and innovation by NASA is welcome when it happens.
- Especially those prophets who, in the tradition of the BIS's moonship, spacesuit, lunar orbit rendezvous, and Daedalus star probe, described these missions many years before anyone else thought them feasible or desirable, who championed such link-ups before they were "politically correct" and consistent with "common wisdom". In particular, I well remember the political flak I personally caught when I advocated a Shuttle/Salyut link-up in print back in 1981-2, and when I published a book in 1984 that had a high-fidelity drawing of a workable androgynous docking system mounted in the shuttle payload bay for docking to a Russian space station.

Just my personal opinions.

JAMES OBERG
Texas, USA

The editor welcomes items of correspondence for publication but regrets that he is unable to acknowledge or reply individually to letters received, except by way of occasional comment in these columns. The right is reserved to abbreviate letters for publication unless specifically requested otherwise.

Taking a Close Look at STS-69 in the VAB

Sir, In the past few years readers accounts of their unique experience at the Kennedy Space Center have graced the pages of *Spaceflight* with increasing regularity, and I would like to add to this fine emerging tradition. I enclose a shot (see below) taken from the deck of Mobile Launch Platform (MLP #1). My colleagues and I were thrilled to be able to walk right up to the exhaust openings in the MLP with the shuttle Endeavour stack for STS-69 looming over us.

JOEL POWELL
Space Information Canada
Calgary, Alberta, Canada



At the lower end of STS-69: Amid the workstands in the VAB High Bay, the STS-69 stack stands ready on the deck of the Mobile Launch Platform with the latter's sound suppression water flow fixtures.

Directly below the belly of the ET is an inverted V-shaped fixture. This is a nitrogen source used to dissipate the build-up of gaseous hydrogen that would be encountered during a hydrogen leak.

JOEL W. POWELL, SPACE INFORMATION CANADA

Manned Mission Count Omits X-15 Missions

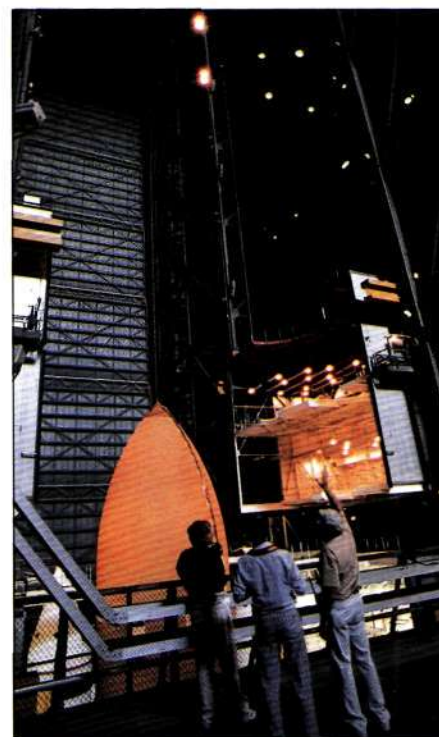
Sir, Shuttle mission STS-71 was widely reported to be the 100th human space flight by the United States. But I would contend that it was in fact the 113th. Remember the thirteen X-15 missions which exceeded 50 miles, and whose eight pilots were accorded Astronaut Wings by the US Air Force?

Although the Fédération Aéronautique Internationale (FAI) defines 62 miles as the altitude where space begins, twice in 1963 X-15 pilot Joseph A. Walker exceeded this limit, reaching altitudes of 65.3 miles and 66.7 miles, respectively. The latter was also the highest altitude achieved during the pioneering X-15 programme.

Further contention to the original claim stems from the fact that USAF Major Michael J. Adams, who died during an X-15 "space flight" in November 1967, is honoured on the NASA Astronaut Memorial at the Kennedy Space Center in Florida (*Spaceflight*, March 1994, p.107).

Perhaps STS-71 should ideally be regarded as NASA's 100th human space flight.

CHAD KHAN
Berkshire, UK



At the upper end of STS-69: Above the vehicle there is still 21 m before the ceiling of the VAB is reached. In the photo, taken on 29 June, Alan Marlow of the BBC and Ove Evju of the Norwegian Astronautical Society are hearing from Ken Thornsley of NASA Media Services Branch Public Affairs how high Saturn V stood above the level where they are standing.

PETER GUALTIERI, WEST KENTUCKY NEWS

SETI

Sir, Please permit me to comment on Paul McKinley's fascinating letter on the possibility of ETI-generated gamma ray bursters (*Spaceflight*, July 1995, p.247).

Though I have developed severe doubts about the existence of ETI in the presently observable universe, I believe a diligent search for any kind of life in space, intelligent or otherwise, deserves all the resources we can throw at it. In a letter that I sent to America's Planetary Society some time ago, I proposed two things: that we search for extra-solar planets by radar and that nearby civilisations could be doing the same thing. I did not fully explain my idea, but would like to expand on it here.

Obviously, our existent, low-power radar would not do the job. But could super-powered microwave lasers (masers) be aimed at the stars in our neighbourhood to see what bounces back? This is not dissimilar to beamed-power for interstellar micro-probes. Also, I suppose that highly advanced radar probes might not consist of simple pulses at single frequencies but rather complex wavefronts.

Therefore, I speculate that sophisticated radar probes beamed at Earth by extraterrestrials may be mislabelled by us as mere noise. McKinley's "fanciful" interpretation of gamma ray bursters is in the same ballpark as this idea. Might gamma rays prove very useful for one-way communications through the interstellar medium?

ROBERT KIRKMAN III
Florida, USA

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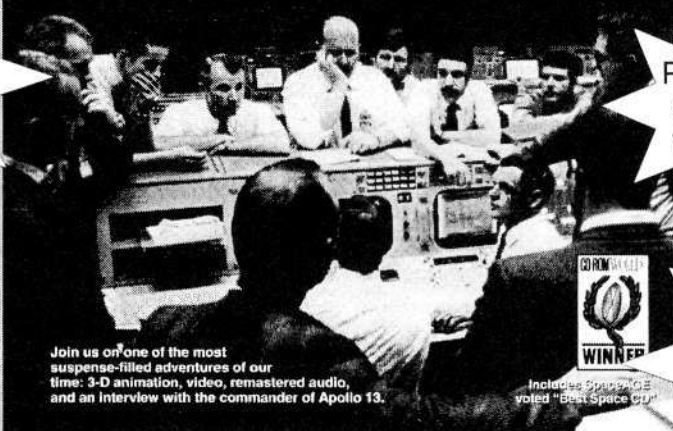
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OK Houston, What a Movie!

At two days, seven hours and 50 minutes into their flight to the Moon the crew of Apollo 13 had just ended a fourth television show from space. They were unaware that none of the TV networks in America, let alone the rest of the world, deemed such a great adventure newsworthy.

But, if life was fair, Jim Lovell would still become the fifth man to walk on the Moon. And on April 13, 1970, the Apollo 13 mission commander was close to realising his boyhood dream - his next TV broadcast would be from the lunar surface.

Just minutes later all that was about to change. The Lovell dream was shattered and media apathy transformed into frenzied activity. The routine procedure of 'stirring' an oxygen tank culminated in an explosion in tank number two, ripping a hole in the service module and causing the first oxygen tank to fail as well.

Apollo 13 was catapulted into the public eye and now, 25 years later, the real-life thriller has been turned into a compelling film about the three stranded astronauts and the hundreds of technicians who worked round the clock to bring them safely back home. Ironically, it was to become one of NASA's finest hours.

Apollo 13, starring Tom Hanks as astronaut Jim Lovell, was premiered in the UK on 6 September and went on general release on Friday, 22 September, just after this issue of *Spaceflight* went to press.

Unusually, the film has received both public and critical acclaim in America but will it capture the imagination of the British public? And what is in it for the space enthusiast - is the story true to the mission, will the detail and special effects stand up to expert scrutiny?

"When anything is recreated on film,

Fred Haise (Bill Paxton), Jim Lovell (Tom Hanks) and Jack Swigert (Kevin Bacon) aboard the "Apollo 13".

BY CLIVE SIMPSON

BIS Member

the human elements are always the most fascinating and engaging. That is the backbone of the Apollo 13 mission," said film producer Brian Grazer. "What happened in this mission could never have been dreamt up. So we felt obligated to capture it and present it in an unequivocally authentic manner".

Preparation for filming Apollo 13 was demanding. Despite what you may think on viewing it, every single shot of the film is original - there are no shots lifted direct from NASA footage of the actual Apollo 13 or any other space mission - providing an opportunity to look at a space mission from a fresh angle and get much closer to the action.

So, in contrast to typical TV coverage of a space mission, *Apollo 13* conveys the feeling of what it was actually like. We go behind the scenes, experience the real pressures and passions, not only during the mission itself but in the build up. And, finally, we share the tensions of the astronauts in their cramped lunar lifeboat on their journey home.

One day during shooting Tom Hanks, as he was being helped into his pressure suit for the first time, hinted that he had always been preparing for this kind of acting role.

"I was a bit too young to latch on to the Gemini programme but when



Tom Hanks starring as astronaut Jim Lovell in the real-life adventure "Apollo 13".

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Apollo began in earnest, I followed the space programme religiously. I knew all the astronauts and I had always been fascinated by the story of Apollo 13", he said.

During one sequence he became totally absorbed and felt he was actually realising his boyhood dream of becoming an astronaut. "When we did the launch sequence in our pressure suits with the helmets on and the air being pumped in, all I could hear was the other two guys talking. Then, when the capsule started to shake . . . I tell you, it felt like it was really happening. It was truly exhilarating - I thought I was on my way!"

Much of the excitement that permeated the film's production came from the fact that the story of Apollo 13 is true. Director Ron Howard said: "The more we kept working on the screenplay, the more I kept learning about the actual mission. And I realised how the truth, in this particular instance, is riveting stuff. It's about triumph under the worst conditions."

As much as any space film, *Apollo 13* has captured a unique piece of modern history in a realistic and entertaining way. In a way it gets closer to 'reality' than any number of TV clips or NASA PR statements, capturing the spirit of these space pioneers and

'Rocket Engine' Competition Winners

Winners to whom a video prize will shortly be dispatched are:

Mr A. Brindley	Derbyshire, UK
Mr M. Cazzella	Rome, Italy
Mr G. Harvey	Glasgow, UK
Mr T. Parimalarangan	Bangalore, India
Mr S. Smirnov,	St Petersburg, Russia

The correct answers are: A. Energiya; B. Ariane-5; C. Zenit; D. Shuttle Orbiter.



"APOLLO 13" ON THE SCREEN

adding a human touch to the astronauts and their families. Exciting to watch and packed with tension, the drama is maintained right up until the end.

The impact of the film was important for director Ron Howard and during actual filming the cast and crew logged up 612 parabolas on the KC-135 aircraft for a total of three hours and 54 minutes of weightlessness, filmed in 25 second bursts.

"Space movies have often avoided trying to show zero gravity because ultimately you can't", he said. "But we were not limited by all the tricks used in the past to simulate it - there are no fake slow motions shots. It was difficult to accomplish, but for everyone involved it was a truly extraordinary experience." This care and attention to detail is evident in the final film. It enabled some remarkably realistic sequences of the astronauts 'floating' and working in space.

The last sequence was shot aboard the USS New Orleans, a US Navy helicopter carrier, which doubled for the USS Iwo Jima, the recovery ship that picked up the Apollo 13 crew on April 17, 1970. Watch out for a real-life appearance of astronaut Jim Lovell -



Astronauts Jim Lovell (Tom Hanks), Fred Haise (Bill Paxton) and Jack Swigert (Kevin Bacon) construct a box to rid the air of the dangerously high level of carbon dioxide within the spacecraft in "Apollo 13".

© 1995 UNIVERSAL PICTURES

who was given a cameo role as the captain of the ship that greets the returning crew. Despite the relief and celebration, it was the end of a dream for Jim Lovell - he never had another chance to go to the Moon. And as

Tom Hanks shakes hands with the man himself, his final words serve as a poignant reminder that, more than 25 years later, we are still almost as far away from the Moon as the crew of Apollo 13.

'Apollo 13 Movie' Competition

Astronautical themes are nothing new to the big screen and this month's competition delves into some of this history as it relates to the newly released *Apollo 13* movie, with an opportunity for readers to win one of the CD-ROM prizes offered.

Prizes: The first correct entry to be opened after the closing date of 2 November 1995 will receive a copy of:

'APOLLO 13 - A Race Against Time'

This two CD-ROM set includes SpaceAge and is autographed by Sy Liebergot, EECOM in mission control for the actual mission.

The next four correct entries to be opened will receive a copy of the one CD-ROM version. Details of these prizes appear in the Deverill Business Systems advertisement on p.356.

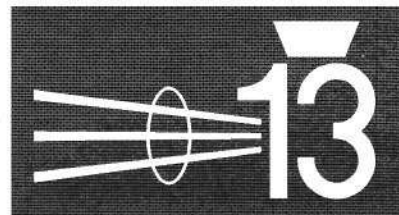
To Enter: Answer A, B or C to each of the following three questions, using each of these letters once:

- The screenplay for *Apollo 13* was co-written by Al Reinert. Reinert had previously made a documentary film about the space programme which received an Oscar nomination. Was it:
A. The Race For Space B. The John Glenn Story C. For All Mankind
- Ed Harris, who plays Eugene Kranz in *Apollo 13* also appeared in *The Right Stuff*. Which of the Mercury seven astronauts did he portray ?
A. Alan Shepard B. John Glenn C. Gordon Cooper
- In 1974 a TV movie was made about the Apollo 13 flight starring Robert Culp. What was the film called ?
A. Houston, We've Got a Problem B. Moonwreck C. Thirteen, The Flight That Failed

Post to: The British Interplanetary Society,
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To arrive by first delivery on 2 November 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.



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SATELLITE DIGEST-281

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Desig.	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Cosmos 2315	1995-032A	Jul 5.13	Plesetsk	Cosmos	825 ?	Jul 6.21	82.91	104.94	970	1,014	[1]
Helios 1A	1995-033A	Jul 7.68	Kourou	Ariane 40	2,537	Jul 14.17	98.07	98.37	680	682	[2]
CERISE	1995-033B				50	Jul 11.16	98.07	98.17	667	675	[2]
UPM/SAT 1	1995-033C				47	Jul 10.07	98.07	98.15	665	676	[2]
USA 112	1995-034A	Jul 10.53	ER	Titan-4/Centaur	8,000 ?	Jul 31	64?	720?	1,300?	39,200?	[3]
Discovery	1995-035A	Jul 13.57	KSC	Shuttle	88,540	Jul 18.01	28.47	90.55	288	315	[4]
TDRS 7	1995-035B				2,225	Jul 31.40	0.03	1,436.27	35,790	35,790	[5]
Progress-M 28	1995-036A	Jul 20.13	Tyuratam	Soyuz	7,250 ?	Jul 23.07	51.65	92.48	394	398	[6]
Cosmos 2316	1995-037A	Jul 24.66	Tyuraram	Proton-4	1,300 ?	Jul 28.42	64.85	675.26	19,104	19,131	[7]
Cosmos 2317	1995-037B				1,300 ?	Aug 1.17	64.85	681.52	19,137	19,413	[7]
Cosmos 2318	1995-037C				1,300 ?	Aug 1.16	64.86	669.12	18,796	19,130	[7]
DSCS-3B 4	1995-038A	Jul 31.98	ER	Atlas-2A	1,040 ?	Geosynchronous orbit ?					[8]

NOTES

- "Musson" navigation satellite operating in the civilian "Tsikada" system, co-planar with Cosmos 2230. Cosmos name used rather than "Nadezhda" or the recently-introduced "Tsikada" (see 1995-002A) because the satellite carries a new "Kurs" marine traffic location and control system.
- Helios 1A is the first French reconnaissance satellite. As well as undertaking photographic work the satellite also reportedly carried an ELINT payload. CERISE ("Caracterisation de l'Environnement Radioelectrique par un Instrument Spatiale Embarque") is studying the Earth's radio environment in support of research connected with the proposed French Zenon ELINT satellite programme. UPM/SAT 1 is a microgravity and telecommunications research satellite, built by the Polytechnic University of Madrid in Spain.
- Classified payload, launched for the Department of Defense: payload is believed to be a SIGINT satellite, possibly in the Advanced Jumpseat series similar to shuttle-deployed payloads 1989-061B (USA 40 deployed from STS-28R), 1992-086B (USA 89 deployed from STS-53) and the Titan-4/Centaur-launched 1994-026A (USA 103). No orbital data from the mission has been released and the orbit quoted above is estimated.
- Shuttle mission STS-70 carried five astronauts: T.T. Henricks (commander), K.R. Kregel (pilot), D.A. Thomas (mission specialist, MS-1), N.J. Currie [nee Sherlock] (MS-2) and M.E. Weber (MS-3). Mass quoted above is that projected for the time of landing. Various biological, and technical experiments undertaken by the crew inside the shuttle orbiter. Landed at KSC July 22.50.
- TDRS 7 ("Tracking and Data Relay Satellite", TDRS G before launch) and the IUS stack deployed from orbiter's payload bay 1995 July 13.83. Orbit of TDRS was initially close to being located over 180 °E. Satellite to be stationed over 189 °E but was apparently initially located over 210 °E.
- Unmanned cargo freighter, carrying supplies to the cosmonauts aboard the Mir Complex. Spacecraft docked at the front (+X) port of Mir 1995 July 22.19.
- Three "Uragan" navigation satellites in the GLONASS system: launched into plane 2 of the system.
- Improved DSCS-3 ("Defense Satellite Communications System") satellite. Mass quoted above includes propellant. No orbital data have been issued for this launch.

For ADDITIONS AND UPDATES see overleaf

Spaceflight Crossword

No. 26

ACROSS

- Rocket motor part
- Destabilises
- Anomalous
- Written reminder
- Word indicating action
- See eye to eye
- Annoy
- Scoop up
- Satellite of Neptune
- Digestive
- Globe
- Tariff
- Extended
- Annexe
- Savours
- Detects

DOWN

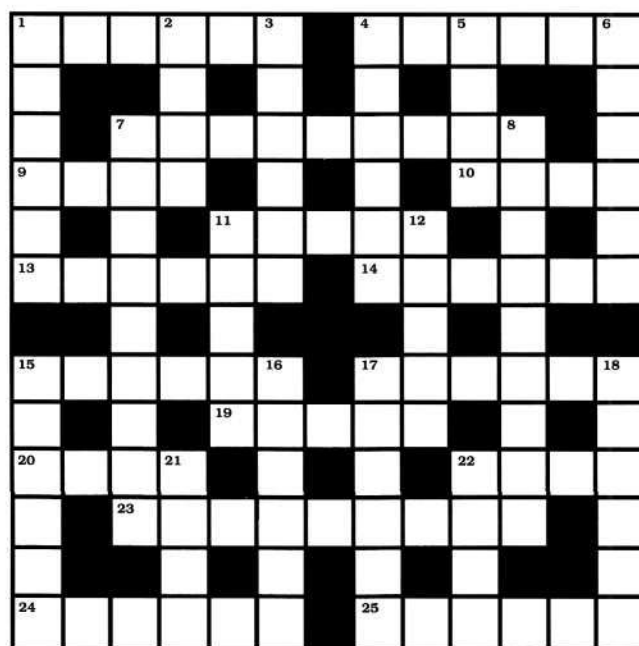
- STS-51 and STS-69 crew member
- Count at lift-off
- Come into view
- New
- Eastern European
- Commander of Challenger disaster flight
- Prompt
- Version
- Permit
- Strayed
- Rocket force
- Stories
- Gains
- Constellation that includes star Deneb
- Departure
- Credit

Solution will appear in the November issue.

Solution to Crossword No.25.

ACROSS: 7. Baudry; 8. Viking; 10. Roswell; 11. Ekran; 12. Enos; 13. Scott; 17. Grabs; 18. Skim; 22. Encke; 23. Doppler; 24. Oberon; 25. Icarus.

DOWN: 1. Aborted; 2. Sunspot; 3. Order; 4. Liberty; 5. Diary; 6. Agena; 9. Black body; 14. Freedom; 15. Skylark; 16. Impress; 19. Aesop; 20. Screw; 21. Space.



SATELLITE DIGEST-281

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Moiniya Space Consultancy.

ADDITIONS AND UPDATES

1978-062A The last orbital manoeuvre for GOES 3 took place during 1994 December 22-25 with the satellite being located over 184 °E. Since then the satellite has been allowed to drift in longitude. By the end of July 1995 it was located over 200 °E in an orbit with a period of 1,435.20 minutes. Although confirmation of the satellite's status has not been received, it is possible that it has been retired.

1979-098B DSCS-2 14 manoeuvred out of the geosynchronous orbit band approximately 1995 April 12: at the time the satellite had been over 84 °E. In fact the satellite had been drifting in longitude for at least nine months: at the beginning of August 1994 it had been over 70 °E and was drifting at that time. The manoeuvres initiated in April 1995 probably marked the actual retirement of the satellite. Add the following orbital data: 1995 June 29.27, 10.40°, 1,464.14 minutes, 36,313 km, 36,355 km

1982-110B SBS 3 manoeuvred off-station over 286 °E approximately 1995 June 1. At the end of July the satellite was still drifting in a 1,441 minutes orbit, and it is unclear whether the satellite has been retired or whether it is being relocated to a fresh longitude.

1983-026B TDRS 1 manoeuvred off-station over approximately 84 °E as previously reported. During 1995 July 26-29 there was a small adjustment made to the drift orbit, but the satellite's longitude had not been stabilised at the end of the month. The NASA press kit for shuttle mission STS-70 gives two longitudes over which TDRS 1 is to be deployed: 139 °E and 222 °E (quoted as 138 °W). The latter longitude appears to be the correct one since the satellite was drifting east over 214 °E at the end of July.

1984-023A INTELSAT 508 manoeuvred off-station over approximately 180 °E during approximately 1994 December 17-18. The satellite has been drifting ever since this manoeuvre and it appears that it has been retired although confirmation of the satellite's status has not been forthcoming from INTELSAT. Add the following orbital data: 1995 January 3.17, 3.14°, 1,480.12 minutes, 36,545 km, 36,743 km

1984-080A Himawari 3 was manoeuvred off-station over 119-120° during the final week of June 1995. It was still drifting in orbit at the end of July and it might have been retired. Add the following orbital data: 1995 July 19.70, 6.02°, 1,442.20 minutes, 35,900 km, 35,912 km

1985-086B Optus-A 1 has been drifting around the geosynchronous orbit band for more than a year and it is believed to be retired, although confirmation of this has not been forthcoming. Add the following orbital data: 1994 August 3.41, 1.40°, 1,443.51 minutes, 35,912 km, 35,952 km

1986-026B BRASISAT A2 manoeuvred off-station over approximately 294-295 °E about 1995 June 19. At the end of July 1995 the satellite was still drifting and it is possible that it has been retired, although confirmation of the satellite's status has not been forthcoming. Add the following orbital data: 1995 June 21.84, 0.07°, 1,437.41 minutes, 35,806 km, 35,818 km

1988-040A INTELSAT 513 was manoeuvred off-station over 306 °E during 1995 July 8-11: no orbital data have been issued since July 11 to show the satellite's orbital status.

1988-091B The date that TDRS 3 was manoeuvred off-station was not reported in last month's issue: the manoeuvre took place at the end of April 1995.

1989-070A Himawari 4 manoeuvred off-station over 139 °E approximately 1995 June 9. The satellite was still drifting at the end of July 1995 and it is possible that it has been retired, although confirmation of the satellite's status has not been forthcoming. Add the following orbital data for the satellite: 1995 June 13.89, 1.02°, 1,437.88 minutes, 35,781 km, 35,862 km

1989-084B The Jupiter Entry Probe separated from the Galileo Jupiter Orbiter 1995 July 12.23 and has been designated 1989-084E.

1992-090A Combined Optus-B 2 core/CZ-2E third stage decayed from orbit 1995 June 29.

1995-027A At the beginning of July 1995 UFO 5 was manoeuvred away from 189 °E and drifted until approximately July 22 when the orbit was stabilised over 73 °E.

1995-029A DBS 3 was manoeuvred from 249-250 °E and relocated over 260 °E during 1995 July 15-28: insufficient orbital data are available to pin-point the actual manoeuvre dates.

1995-030A Atlantis (STS-71) landed at the Kennedy Space Center 1995 July 7.62.

ZENIT "SATELLITE EJECTION UNITS"

A characteristic of all Zenit-2 launches has been the presence of four objects in orbit along with the satellite and Zenit-2 second stage, the orbits of these four objects having apogees which are significantly higher than those of the other objects from the launch. It is now known that these objects are covers for four solid-propellant motors which are fired to separate the rocket stage and the payload.

MASSSES OF TSELINA-2 SATELLITES

Tselina-2 is the Russian programme name for the large ELINT satellites which have been launched using the Cosmos cover name into 71°, 850 km orbits: there were two payload tests using the Proton-4 launch vehicle before the Zenit-2 launches commenced. Calculations suggest that the Proton-4 payloads were approximately 3,250 kg at a "maximum", and therefore the virtually identical Zenit-2 payloads will have approximately the same mass: this is far less than the approximately 9 tonnes which the Zenit-2 could theoretically launch into these orbits.

Therefore, the masses of the following satellites should be amended to "3,250 kg ?":

Proton-4 launches:

1984-106A	(15333)	Cosmos 1603
1985-042A	(15755)	Cosmos 1656

Zenit-2 launches:

1985-097A	(16181)	Cosmos 1697
1985-121A	(16434)	Cosmos 1714
1987-027A	(17589)	Cosmos 1833
1987-041A	(17973)	Cosmos 1844
1988-039A	(19119)	Cosmos 1943
1988-102A	(19649)	Cosmos 1980
1990-046A	(20624)	Cosmos 2082
1992-076A	(22219)	Cosmos 2219
1992-093A	(22284)	Cosmos 2227
1993-016A	(22565)	Cosmos 2237
1993-059A	(22802)	Cosmos 2263
1994-023A	(23087)	Cosmos 2278
1994-077A	(23404)	Cosmos 2297

Cosmos 1714 failed to reach its intended orbit due to a malfunction with the Zenit-2's second stage propulsion system - although no Russian or Ukrainian literature issued in support of the commercialisation of this vehicle has acknowledged the failure.

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

16 October 1995 7 - 8.30 pm

ESA's ARTEMIS Mission: An Operational Test of Ion Propulsion

Dr D.G. Fearn
DRA Farnborough

Ion propulsion, the "ion drive" so often mentioned by science fiction authors, is soon to have an opportunity to demonstrate its capabilities on ESA's ARTEMIS experimental communications satellite. Ion thruster systems from the UK and Germany will be used for operational north-south station-keeping for the 10 years life of this satellite. The lecture will explain the principles behind this technology and will then describe its application to communications satellites, concentrating on ARTEMIS and the resulting operational and financial benefits.

1 November 1995 7 - 8.30 pm

Mini Black Holes

Bernard Carr
Queen Mary & Westfield College

Small black holes may have formed in the early Universe when the density was very high. Such primordial black holes are of particular interest because they are the only ones small enough for quantum effects to be important, those smaller than 10^{15} g having evaporated by now as a result of the Hawking process. We discuss their possible observational consequences.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

22 November 1995 7 - 8.30 pm

SAREX

Mr Will Marchant

The Shuttle Amateur Radio Experiment (SAREX) is an amateur radio station flown on about half of the NASA Space Shuttle Missions. It is primarily used for contacts between the astronauts and school students during the mission. The speaker will present a SAREX related slide set that he has created for use by NASA Educational Personnel.

Change of Date

6 December 1995 7 - 8.30 pm

Space, The Medical Challenge

Dr Mike Harrison
Defence Research Agency Centre for
Human Sciences, Farnborough

Radiation, vacuum and absence of gravity combine to make space an environment that is overwhelmingly hostile to life. Add confinement and isolation in a fragile habitat, a vulnerable life support system, and the remoteness of help and rescue, and you have the ultimate human challenge - the permanent occupation of space. The talk addresses some of the key medical issues involved in responding to that challenge.

SYMPOSIA

For the following symposia Advance Registration is necessary.

Registration Forms are available from the Executive Secretary. Please enclose a sae.

Offers of papers are invited. Please send details to the Executive Secretary.

27 March 1996 10 - 4.30 pm

Call for Papers

Space Transportation

For over a decade the BIS has run symposia on the subject of space transportation. These are intended to provide a forum to cover all aspects of the space infrastructure including the rationale for infrastructure development, system concepts and technology issues. In the past these symposia have been key to the development of HOTOL, Skylon, the Polar Platform and UK thinking on space industrialisation as a part of mankind's future.

Organiser: Mark Hempell

1 June 1996 10 - 4.30 pm

Society/Russian/CIS Astronautics

The Society is holding the 11th Symposium on the Soviet, Russian and the CIS space programmes. It is acknowledged as one of the foremost meetings to review current and historical programmes. It attracts Fellows and participants from all over Europe and the United States. Advanced registration is necessary and application forms can be obtained from the Executive Secretary. Please include an SAE.

14 - 20 July 1996

Cospar '96 Commission F Assembly

The next biennial assembly of COSPAR, the international Committee for Space Research, will take place in Birmingham. These biennial Commission F conferences (the last was held in Hamburg in 1994), provide one of the most important forums for the discussion of the present status and future directions of space research.

In recognition of the part BIS has played over the past decade in publishing scientific research papers on the relatively new and now rapidly evolving subject of planetary environmental engineering - terraforming - the Society has accepted the invitation of COSPAR to co-sponsor the F3.4 symposium. The organiser of the programme of the symposium *Implanting Life on Mars* is Prof. Robert H. Haynes (President of the Royal Society of Canada) and it is scheduled to be the three hour evening session of the opening day of the conference July 15, 1996.

Fuller details will be published at a later date.

The 50th Annual General Meeting of The British Interplanetary Society held on 12 August 1995

With the President, Dr P.T. Thompson, in the Chair and 24 other Fellows present, the meeting approved *mem. con.* the four Resolutions* that were on the Agenda.

In his closing Remarks, the President referred to the sad loss during the last year of the Founder of the Society, Philip E. Cleator, and the Past President, Anthony T. Lawton, referring to their support for the Society and saying that they will both be greatly missed.

* Elected to the Council of the Society are: Mr R. Hall, Mr K. Lavanchy, Dr P. Moore and Dr P.T. Thompson.

JBIS



The October 1995 issue of the Journal of the British Interplanetary Society is now available and contains the following papers:

Terraforming (Part V)

The Economic Viability of Mars Colonization

Biological Aspects of the Ecopoiesis and Terraformation of Mars:
Current Perspectives and Research

Genetic Modification and Selection of Microorganisms for Growth on Mars

Terraforming Mars: Conceptual Solutions to the Problem of Plant Growth in Low Concentrations of Oxygen

Directed Panspermia.2. Technological Advances Toward Seeding Other Solar Systems and the Foundation of Panbiotic Ethics

Environmental Ethics and Planetary Engineering

Topics to be covered in forthcoming issues of *JBIS* include:
Exobiology (Part V) SETI, Space Science at MSSL, Electric Propulsion and Practical Robotics (part I).

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Dr Patrick Moore, CBE
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Professional Affiliation Job Position or Title

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Signature Date

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acceptance of
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The International Magazine of Space and Astronautics

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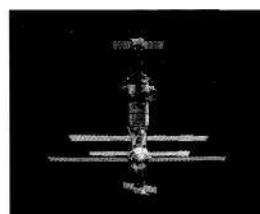
Mir Rendezvous

STS-63 Mission Highlights

Launch Date: 3 February 1995



The 20th orbital flight of Discovery. The crew included as mission specialists Russian Vladimir G. Titov, Janice Voss and British born C. Michael Foale. The prime objective of the mission, and the first stage in the American-Russian space station programme, was to make a close rendezvous with MIR to test the procedures to be used on Mission STS-71 to dock the shuttle with the space station. The video runs for approximately 1 hour and includes some spectacular rendezvous images of the MIR space station.



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Reduced rates are available for those under 22 or of 65 years or over. For (a) the amount is £26 (US\$47). For (b) the amount is £39 (US\$71).

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Front Cover: In the early morning light the Soyuz TM-22 launch vehicle is rolled out to the launch pad at the Baikonur Cosmodrome on 1 September 1995 in preparation for the launch of the EuroMir 95 Mission.
E. RUDOLF van BEEST

EuroMir 95 Lift-off

On the 30 August, the author joined the ESA group of visitors to the Baikonur Cosmodrome for the start of the EuroMir 95 mission. He flew to Leninsk the following day and attended the events leading to the launch on 3 September.

The Mission

EuroMir 95 is the second ESA mission to the Mir Space Station. Highlights of the mission include a five-hour spacewalk by Thomas Reiter on 20 October and later, probably on 4 November, a docking with Space Shuttle Atlantis, carrying four Americans and a Canadian.

The visual beginning of the EuroMir 95 mission took place two days before launch early in the morning of 1 September. At exactly seven o' clock the Soyuz TM-22 launch vehicle was rolled-out of the MIK to be transported to the launch pad. It was a very exciting experience to attend the roll-out 'live'. You are so close. You can walk or run alongside the train and even in front of it..., but do not fall. Weather and light-conditions were beautiful. A clear sky and rising Sun. Great!

Later, during the erection of the Soyuz-rocket, there were the same very favourable circumstances. It all happens right in front of you. Noteworthy is a remarkable new phenomenon on the launch-platform: the presence of a good number of persons, wearing bright blue uniforms with RKA arm-patches.

At the beginning of the well-attended press conference with the EuroMir 95 prime and back-up crews seated behind the large window of the quarantine room the cosmonauts were presented by Vladimir Ivanov, commander of the Russian Space Forces, Pjotr Klimuk, head of the cosmonaut



On 2 September, the crew members, seated behind the large window of the quarantine room, speak to the media. Left to right: ESA astronaut Thomas Reiter, commander Yuri Gidzenko, flight engineer Sergei Avdeev (prime crew); Christer Fuglesang, Gennadi Manakov and Pavel Vinogradov (back-up crew).

E. RUDOLF VAN BEEST

training centre in Star City and by Yuri Koptev director general of RKA (Russian Space Agency). Maybe this was to prove that changes are in progress.

Thomas Reiter said that, besides the Russian language, he had found training for his spacewalk to be very heavy going. He was very thankful of the support he had had from Manakov and Avdeev.

The cosmonauts were not allowed to take personal belongings exceeding 1.5 kg in weight with them. For this reason Thomas Reiter had chosen to take tapes instead of heavy books. Gidzenko's reaction was that, if Reiter would like to read in space, he could



Thomas Reiter suiting up on launch day assisted by his backup Christer Fuglesang (right).

ESA (supplied courtesy ROLF H. SCHOEVAART)

read the on-board documentation. There is a lot of it, Gidzenko added.

The question whether the cosmonauts expected problems to occur during the coming flight, considering the age of the space station, caused an almost simultaneous reaction from Manakov and Avdeev. They admitted that there had been problems, but these were now solved.

Manakov and Vinogradov will soon start preparations for the joint Russian-French space flight in May 1996 when they will be accompanied by the CNES-astronaut Mrs Claudie Andre-Deshays. Fuglesang said that he would keep on training in Russia to

The Soyuz TM-22 launch vehicle is erected on the launch pad on 1 September.

E. RUDOLF VAN BEEST



learn to operate the Soyuz lifeboat that will be used for the International Space Station.

The Launch

An unexpected but pleasant surprise, before the walk-out was having the opportunity to watch the cosmonauts donning their space suits.

The back-up crew, Manakov, Vinogradov and Fuglesang, had already come out and taken up their positions alongside the 'cosmonaut-bus', when the prime-crew, Gidzenko, Avdeev and Reiter, walked-out. They were greeted by applause and cheering from all those present. After the traditional goodbye ceremony, with the cosmonauts saluting Vladimir Ivanov, commander of the Russian Space Forces and chairman of the Government Committee, who wished them a successful flight, the spacemen stepped into the bus that would take them to the launch pad.

A few minutes before three o' clock the gantries, which had surrounded the Soyuz rocket, swung away leaving behind the 'swing-arm', carrying umbilicals for propellant and electrical services, as the only visible connection between rocket and launch pad. At exactly three o' clock a deep rumbling became audible, the swing-arm swung away, clouds of smoke rose up and then the white-coloured Soyuz lifted-off on a tail of fire and smoke. The spacecraft vanished quickly from sight. Within just some tens of seconds only an orange-red glowing spot was visible in the deep blue sky and a moment later this spot had also disappeared. After about two minutes the message was received that the boosters had separated. People congratulated each other, applauded, cheered and laughed. The Soyuz TM-22 reached its orbit after nine minutes

The EuroMir 95 crew members pose in front of their Soyuz TM-22 launch vehicle on Sunday 3 September 1995. From left to right: Sergei Avdeev, Yuri Gidzenko and Thomas Reiter.

ESA (supplied courtesy ROLF H. SCHOEVAART)



Walk-out of the Soyuz TM-22 crew on 3 September. In front is Yuri Gidzenko (commander) followed by Sergei Avdeev (flight engineer) and Thomas Reiter (ESA astronaut).

E. RUDOLF VAN BEEST

and successfully docked two days later with Mir.

In Conclusion

Baikonur is undergoing a profound transformation from military to civilian control. Russia's increasing presence on the international commercial satellite launch market and large role in the International Space Station underlie these changes. Within two years non-military launches will be managed by civilian employees from the Russian Space Agency (RKA) and its industrial partners. There are already about 700 RKA workers at Baikonur, many of whom are involved in the preparations and launch of Soyuz and Progress spacecraft.

The role of the Space Forces will be sharply reduced as they continue to manage only the purely military space programme and maintain a presence in the region as a security force.

The ESA-group was confronted with tight security measures. We were not allowed to walk around in Leninsk in broad daylight, because it was unsafe for foreigners to do this, officials said. There is a continuing crime problem in Leninsk that has been worsened by the departure of thousands of Russian soldiers whose place has been taken by thousands of formerly nomadic Kazakhs who have illegally settled in Leninsk, occupying buildings and refusing to move.

Military and civilian authorities hope that the long-expected agreement on the status of Baikonur between Russia and Kazakhstan will improve living conditions generally, especially considering the presence of a growing number of western aerospace engineers, who will spend weeks at Baikonur/Leninsk in the near future making demands for higher standards of hygiene and comfort. ■

JBIS



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EuroMir 95

Underway But Return Delayed

September 3 saw the safe launch of the 20th main expedition to the Mir space station. The three-man crew consisted of two Russians - Lt-Col Yuri Gidzenko and Sergei Avdeev - and the European Space Agency (ESA) astronaut Thomas Reiter. The three men were to take over the duties of the Mir space station from the EO-19 crew of Anatoli Solovyov and Nikolai Budarin who had arrived on June 29 in the US Space Shuttle Orbiter "Atlantis".

Work of the EO-19 Crew

During their relatively short mission to the Mir space station Solovyov and Budarin had conducted a re-docking of the Kristall module and three spacewalks to deploy a solar panel on the Spektr module and install the French-Belgian Miras spectrometer to that module. During August they continued maintenance operations and conducted experiments including smelting experiments in the Gallar unit. This is the first time that these experiments had been reported for several months.

The men also unloaded the unmanned cargo spacecraft Progress M-28 and oversaw refuelling operations, conducted automatically by the cargo ship, to top up the reserves of the base block module. They replaced one of the main gyrodyne stabilisers in the Kvant-2 module with a new unit delivered by Progress and reportedly used a lute to seal other Gyrodyne cases by encasing electrical sockets which appeared to be leaking.

EuroMir 95

On 25 August 1995, ESA reported that final preparations were underway in Europe, Russia and Kazakhstan for the launch of EuroMir 95, the second ESA mission to the Mir space station scheduled for launch from the Baikonur Cosmodrome, Kazakhstan, on 3 September.

The prime and back-up crews for the mission, which ESA described as "ambitious" arrived at the launch site on 23 August. They spent the days leading up to the launch reviewing their flight plans and having a final medical check-up.

The prime crew of Soyuz TM-22 consisted of Gidzenko, Avdeev and Reiter, the second German to represent ESA on Mir. Their reserves were ESA astronaut Christer Fuglesang and Russian cosmonauts Gennadi Manakov and Pavel Vinogradov. The prime crew was confirmed formally for the mission one day before launch.

The EuroMir 95 mission followed the shorter EuroMir 94 flight conducted in October/November 1994 by German

BY NEVILLE KIDGER, FBIS

Leeds, UK

Ulf Merbold. During that mission the researcher returned some 34 blood samples, 85 urine samples, and 125 saliva samples. However, a power shortage on flight day 8 of that mission resulted in the partial loss of four of the frozen blood samples. The failure of the CSK-1 furnace during the flight also resulted in the loss of four materials science experiments which had to be conducted by the Russian crew left aboard following their repairs of the furnace with equipment delivered on board a Progress M cargo ship.



The official portrait of the prime crew of EuroMir 95. From left to right: Yuri Gidzenko, Mission Commander, Thomas Reiter, ESA Astronaut, and Sergei Avdeev, Flight Engineer.

TsPK/ESA (supplied courtesy ROLF H. SCHOEVAART)

The EuroMir 95 science equipment was already largely aboard Mir as the crew prepared for launch, the final elements (weighing about 10 kg) needed for the start of the mission were to be taken aloft by Reiter.

The bulk of the ESA equipment (about 335 kg) was flown to Mir in June aboard the Spektr module and in July on Progress M-28 (TK-228). The remainder of the ESA equipment (about 85 kg) was to be delivered on Progress M-29 (TK-229) scheduled for launch in early October.

ESA said that the main goals of this flight were to accomplish an intensive programme of 47 scientific experiments, over 530 working hours, focussing on scientific research in the



unique microgravity conditions found in Earth orbit and to prepare for future missions in the framework of the International Space Station.

One of the highlights of EuroMir 95 was set for 20 October, when Reiter was scheduled to conduct a five-hour spacewalk, the first by an ESA astronaut, to install a European experiment on the outside of Mir's Spektr module. The Russian crew members were expected to conduct two other EVAs during the mission.

Another major event was to be the docking of the US Space Shuttle Atlantis with Mir, scheduled for November. The Shuttle and Mir crews, which include Russians, Americans, a Canadian and a European, are to work together for a few days before the Shuttle returns to Earth.

Two Progress M cargo ships were also to dock with the complex during the EO-20 crew's stay aboard.

In addition to his scientific work, Reiter had special responsibilities as the mission's flight engineer, the first time an ESA astronaut has been assigned this role in the framework of the Russian manned spaceflight system. His tasks included maintenance of some of the space station's numerous onboard systems and the joint performance of Russian experiments with Avdeev. Gidzenko, the Russians reported, would not be directly involved with the EuroMir 95 science work.

The mission was scheduled to end on 16 January 1996 with a landing in Kazakhstan. A new crew was scheduled to arrive to take over control of the space station on 10 January.

Soyuz TM-22 in Flight

The Soyuz TM-22 spacecraft carrying Gidzenko, Avdeev and Reiter was launched by a Soyuz-U booster from the "Gagarin" pad at the Baikonur cosmodrome in Central Asia at 0900:23.115 (all times GMT) on 3 September. The call sign of the crew was "Uran". For Gidzenko and Reiter it was their first mission into space - Avdeev previously flew to Mir in 1992.

"This mission marks a major leap forward in European manned space experience," said ESA Director for Manned Space Flight and Microgravity Jorg Feustel-Bechl, who watched the launch from a nearby viewing site. "It will provide European scientists with



The successful launch of Soyuz TM-22 on 3 September 1995, 15h00 (Baikonur time). EuroMir 95, the second joint ESA-Russian mission to the Mir space station, will be the longest manned mission in European space history and will include the first spacewalk by an ESA astronaut.

ESA (supplied courtesy ROLF H. SCHOEVAART)

unprecedented data on long-duration space flight and further strengthen ESA's relationship with the Russian space programme."

The initial checks of the Soyuz TM-22 spacecraft revealed no problems and the first two orbit corrections had been made within 4½ hours of the launch. Docking was set for 5 September.

Progress M-28 Departs

As has become routine for Mir missions, once the manned spacecraft in orbit was checked out and the approach to the Mir complex begun the unmanned cargo ship attached to the docking port to be used for the manned docking was discarded. Having been packed with used equipment and other trash the Progress M-28 cargo ship, attached to the -X (forward axial) port of the Mir base block, was commanded to undock from the space station at 0610 on 4 September. Later that day it was commanded to a destructive reentry over the Pacific Ocean.

Soyuz Docks

After first circling the complex at a distance of 90-120 m the Soyuz TM-22 craft executed a flawless approach to the front port of the Mir complex, vacated by Progress M-28 the previous day. Gidzenko monitored the automated systems of the spacecraft as TV showed the spectacle of the deployed solar panels of the Spektr module facing the approaching Soyuz.

The soft docking took place on schedule at 1029:54 on 5 September. One orbit of the Earth later, at 1201:12, the hatches between Soyuz and Mir were opened and Reiter and his colleagues were greeted by Solovyov and Budarin. Solovyov banged the hatch three times with his hand before opening it. The traditional gift of bread-and-salt was offered by the resident crew and later gifts were exchanged. Reiter hung up an ESA flag and a EuroMir 95 decal before spending time speaking with officials and press representatives.

The cosmonauts then settled down to begin their work in earnest for the short period of joint flight. For Solovyov and Budarin their task was to pass on their experience and knowledge of the workings of Mir to the Uran crew.

Reiter began his medical programme collecting samples of bodily fluids. One report said that Reiter found the first days of the flight difficult suffering insomnia and headaches. The report said that he took medication for the complaints and spoke on a regular basis with his reserve Christer Fuglesang.

Soyuz TM-21 Returns

On 11 September, Solovyov and Budarin climbed into their Soyuz after saying farewell to the EO-20 crew and

undocked at 0327. They fired the engines of the craft to begin the descent at 0556 and the ship spilt into its three sections. The manned descent cabin, slowed by its huge parachute touched down on the Kazakh steppes at 0652 some 302 km north-east of the city of Arkalykh, reportedly well away from its aiming point. The recovery crews found the capsule and the two man crew in good condition. The men were flown back to Moscow's Star City the same day.

Return Delayed

Spaceflight understands that the mission of Thomas Reiter and his colleagues has been extended. For reasons unclear at this writing the launch of the next - EO-21 - crew has been postponed six weeks to 21 February 1996 making the EuroMir 95 mission even longer (about 180 days). The EuroMir 95 payload chief George Hiendlmeier told *Spaceflight* on 4 October:

"We are presently working on a layout of the experimental programme (of EuroMir 95) but there will not be any extra (new) experiments (because of the extension of the mission). The time for the given experiments had already been cut very tight and we can see some relief and room for improvement."

More details will follow in the next part of Mir Mission Report in which we will follow the mission of Thomas Reiter and examine his science programme in detail. The EuroMir 95 mission has a home page on the Internet World Wide Web and can be found at: [HTTP://www.op.dlr.de/EUROMIR95/](http://www.op.dlr.de/EUROMIR95/)

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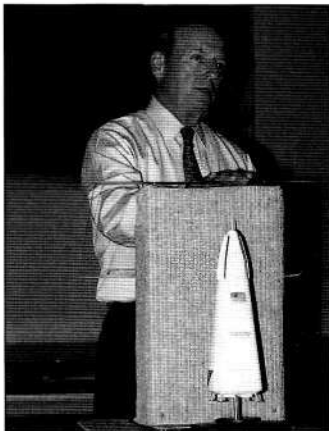
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"Come Fly With Me"



Pete Conrad at the Kennedy Space Center press briefing on 28 July.

PETER GUALTIERI, WEST KENTUCKY NEWS

Sir, As flight manager for the DC-X single-stage rocket, Apollo 12 moonwalker Pete Conrad, briefed the assembled press at KSC, where the DC-X Flight Operations Control Center (FOCC) is undergoing modifications, on 28 July.

Housed in an ordinary 40 foot commercial trailer the FOCC contains the real-time data system (RTDS), the ground control system that monitors and controls the DC-X and its ground support systems. The FOCC is operated by a three-member flight crew!

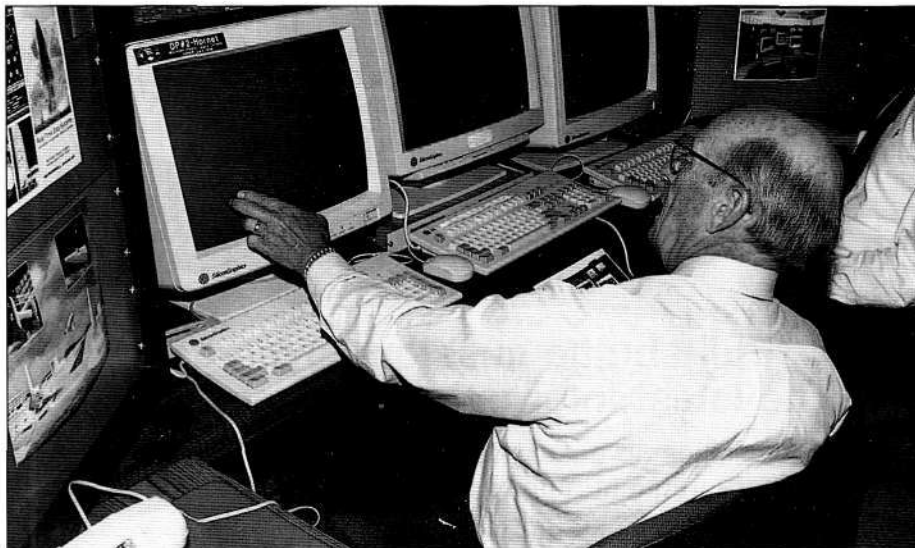
The vehicle itself has been transferred to NASA for an upgrade, including a lighter fuel tank, and will be designated the DC-XA. Its four LOX and LH₂ RL-10 engines are on loan from Pratt & Whitney, the manufacturers, and are similar to the Centaur engine.

PETER GUALTIERI
Detroit, USA

Ed: Test flights are scheduled to resume, with the DC-XA version, in 1996.

Launch control for the DC-X differs somewhat from Houston's new multi-million dollar control centre. The photo shows Pet Conrad explaining how the three computers mimic a typical three-tube all-electronic cockpit. Eventually an operator will have the same cockpit in the FOCC as will be installed in the vehicle allowing complete control of the flight by remote operation.

PETER GUALTIERI, WEST KENTUCKY NEWS



International Astronauts

Sir, With regard to the letter in June 1995, p.213, in which the new astronaut candidates are revealed, I would appreciate it if someone could tell me in which CSA and NASDA groups were David R. Williams and Takao Doi selected, as well as when and who else were selected in those respective groups.

J. VASCO
Cape Town, RSA

Nick Deakin writes: Takao Doi, PhD (NASDA), 40, was born in Minamitama-gun, Tokyo, Japan. He earned a master of engineering degree in 1980 and a doctorate in aerospace engineering in 1983, both from the University of Tokyo. His major field of study was space propulsion systems.

Selected in 1985, he was an alternate payload specialist for STS-47, Spacelab J, in 1992. Dr Chiaki Mukai, MD was also an alternate for that flight. She was also selected in 1985 and later flew aboard the STS-65 mission (IML). The astronaut they were both alternate to was Dr Mamoru Mohri who actually flew aboard the STS-47 Spacelab and was also selected as a NASDA astronaut candidate in 1985.

David R. Williams, MD, 40, was born in Saskatoon, Saskatchewan. He earned a doctorate of medicine and a master of surgery from McGill University in 1983.

Prime Minister Miyazawa (centre) receives the three Japanese mission specialists for STS-47/Spacelab-J on 5 May 1992. Dr Mohri (seen to the left of the Prime Minister) flew on the mission which was launched on 12 September 1992. Drs Mukai and Doi are seen on the right. NASDA



Launcher Costs

Sir, The article by Neville Kidger entitled "Soyuz Replacement" (*Spaceflight*, 37, 7, p.248) points out that in recent years the cost of building a Soyuz launcher has increased from 900,000 to 12 billion roubles, which is no more than £1.5 million at the current exchange rate.

This would indicate that either Russian engineers are very poorly paid or that the space nations in the west are getting very poor value for money from their rocket suppliers. For example an Ariane launcher costs more like £40 million.

Perhaps a representative of the space industry could explain this discrepancy.

GEORGE THOMPSON
London, SE9

Dr Bob Parkinson, Matra Marconi Space writes: The short answer to Mr Thompson's question is that Russian engineers are incredibly poorly paid. But it can be misleading to compare matters on a simple exchange rate. In the "bad old days" the Russian economy (particularly in the aerospace sector) ran on quite independent lines to the West. What you could buy for your money depended on what was available - not how much money there was. And while, since 1989, things have changed somewhat (and aerospace engineers have probably got relatively poorer in the Russian economy), there is still no direct comparability.

The Soyuz launcher ought to be cheap by now. There have been over 1400 launches with this vehicle, and because the vehicle uses wrap-around boosters and common engines that means a production of 5600 booster stages and 7000 engines! If those had been built by a Western company, "learning factors" would have reduced the production cost to about 15% of its original value. In contrast, the longest serving Western launchers (Atlas and Delta) are only in the 200 - 300 range.

One way of estimating the cost of a launch vehicle, pioneered by Dietrich Koelle in Germany, is to enquire how many man-years were required in the construction. A "Koelle man-year" is a gross figure, including all overheads and support costs, and currently in Europe runs to about £130,000 per man-year (i.e. 3-6 times what we pay an individual engineer). If we use Koelle's Transcost model to estimate the cost of the Soyuz launcher in Western terms, the first unit production cost would be about £220 million, and with the learning factor applied at unit 1400, about £32 million. Russian "learning factors" may not be as good as Western values - production units were set up with so many staff and facilities, and there was little incentive to reduce them. But if the current cost of a Soyuz launcher is 12 billion roubles, that implies an equivalent "Koelle man-year" rate in the range of 7 - 20 million roubles per man-year, or (at an exchange rate currently 7500 roubles to the pound) £1000 - £2500 per man year. And that is probably what Russian engineers are getting paid.

However, if Russian launchers start getting sold in quantity on the Western market (e.g. Proton), I expect that their engineers will expect to see their salaries capable of buying Western products, and I doubt that you can buy a Soyuz launcher today for £1.6 million.

On Display

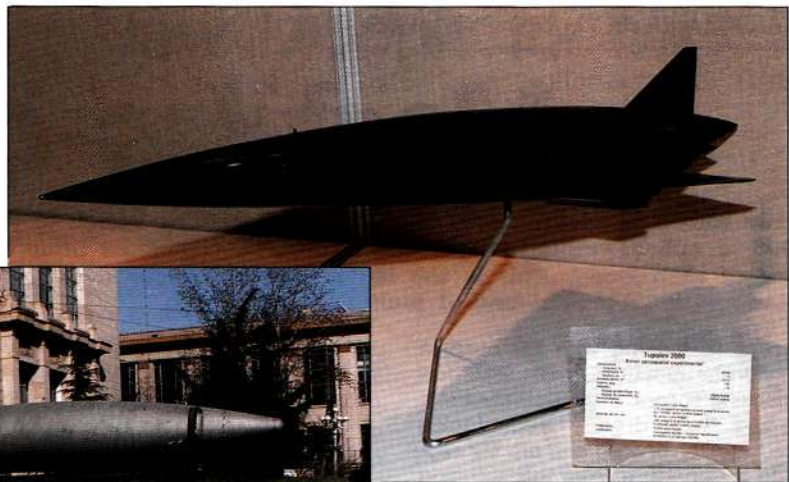
Sir, Thank you for publishing such revealing articles on ex-Soviet rockets and spacecraft. The enclosed photographs might possibly be of interest to readers.

FERDINAND C.W. KÄSMANN
Frechen-Königsdorf, Germany



Top right: A model of the Tupolev 2000 displayed at the 1993 Paris Salon. The information given is that it is an Experimental Aerospace Plane with Turbo-Stato-Rockets. Technical data shown are: Fuel/Oxidiser: H_2/O_2 - 35-50 t; Launch weight: 70-90 t; Span: 14 m; Length: 55-60 m; Height: 12-13 m; Wing area: 160 m^2 ; Wing sweep: 70° .

Above: The "Dong Feng 2" (CCS-1) on its Meiller-type transport/launch trailer in front of the Beijing Military Museum in March 1994.



The previously rather elusive "Dong Feng 1" (East Wind One) SSM as displayed inside the central hall of the Beijing Military Museum. It was taken in March 1994 and shows the Chinese equivalent of the Korolev R-2 (SS-2), the stretched version of the R-1 (SS-1a) A-4-look-alike.

Tragic Death of Former Astronaut

Sir, Reinhard Furrer (54), one of the German scientist astronauts, died on 9 September in the crash of a 'Messerschmitt 108 Taifun (Typhoon)' aeroplane. The accident happened after the official end of an 'old-timer' aircraft show at the Johannisthal Airfield in the eastern part of Berlin. The 39 year old pilot of the aircraft was killed too.

Dr Reinhard Alfred Furrer was born on 25 November 1940 in Wörgl/Kufstein, Austria (then part of Germany). He attended secondary school at Kempten/Allgäu, studied physics at the Universities of Kiel and Berlin and received his PhD in physics in 1972. After that Dr Furrer was

a researcher at the University of Stuttgart and at the Free University of Berlin and, a visiting scientist at the University of Chicago's Argonne National Laboratory.

In 1977 he was one of the five German applicants to the position of European Space Agency (ESA) Spacelab-1 payload specialist, but eventually he was not selected.

On 17 December 1982 the Federal German Aerospace Research Establishment (DFVLR) announced the assignment of Dr Furrer and Dr Ernst Willi Messerschmid as the German payload specialist candidates for the Spacelab D-1 mission.

Reinhard Furrer made his only space flight, logging 168 hours, 44 mins and 51 secs in space, together with five American astronauts, Dr Messerschmid and ESA astronaut Wubbo Ockels on the highly successful STS-61A mission in October and November 1985. During the flight the crew performed life sciences and material processing experiments using various ESA-developed facilities.

Since 1987 Dr Furrer, who had a commercial pilot's license, was a professor in space flight technology at the Free University of Berlin. He had a supporting role for some of the experiments carried out on the second German Spacelab on the STS-55/Spacelab D-2 mission in 1993.

ROLF H. SCHOEVAART
The Netherlands

Ed: We hear also from Thorsten Frahm, Berlin about this tragic accident saying that it happened only a few kilometres from his home.

Deceased Cosmonaut

Sir, The date of death of the cosmonaut-

Dr Reinhard Furrer during one of the medical experiments on the STS-61A/Spacelab D-1 mission.

NASA (Supplied courtesy of ROLF H. SCHOEVAART)



candidate Bui Thanh Liem (Vietnam) shown only by month and year in the Molchanov list in the January 1995 issue is 30.09.1981. He died in a MiG-21 crash. This information appears in "Selections of Cosmonauts and Astronaut Groups", published (in Russian) by Videokosmos.

THORSTEN FRAHM
Berlin, Germany

Quiz Picture

Sir, The photograph of the Mir cosmonaut printed in the September issue of the Mir Mission Report occurs twice in the 1991 edition of the Cosmonautics annual (Machinostroenie Press and Matson Press).

According to the book, the photograph was taken during the second EVA of Viktor Afanasyev and Musa Manarov in January 1991. As there is no discernible moustache I assume the cosmonaut to be Afanasyev, possibly standing next to the Kvant 2 module.

PHILIP BARNES
Hong Kong

Modules at Mir

With the launch of Spektr on 20 May and the upcoming launch of Priroda in 1996, a minor, yet crucial procedure must be conducted prior to the docking of each vessel. This is the moving of the drogue docking 'cone' receptacle within the Mir forward multiple docking hub.

Spacecraft docking with Mir carry a docking probe mounted within their forward docking collars. Previous Salyut stations had two drogue receptacles mounted axially, forward and aft. Mir represented a departure from this tradition with the addition of a multiple docking adapter with four radially mounted docking ports around the forward axial port.

The designers of Mir, chiefly former cosmonaut Konstantin Feokistov, found that it was impractical to place drogue receptacles in each of these new ports, due to limited space, because this multi-docking hub was also required to double as the EVA airlock, at least initially until the arrival of the Kvant-2 module. Instead they placed only two docking cones in the forward hub with the intention that orbiting crews would move the extra cone to the desired position, radially within the hub, as the need arose.

In February 1986, Mir was launched with this third receptacle mounted in its upper, +Y docking port (see below for docking hub key). This was done to facilitate the transfer of Kvant-2 from the forward, -X port, where it initially arrived, to the +Y position where it would be permanently berthed.

The 'transfer' involved the Kvant-2 Ljappa remote arm extending to one of two Ljappa fixed mounting points on the forward hub end of Mir and locking on. Then, the Kvant-2 would undock from its arrival port and swing itself over 90 degrees to the upper +Y port of the multi docking hub.

Placement of the heavy expansion modules at Mir is predetermined and relies on several constraints, ranging from mass dynamics, solar panel clearance and the individual mission requirements of each module. Although not known publicly at the time, the placement of each module was preset prior to the launch of the Mir station itself.

The breakup of the Soviet Union caused a major delay in the complete assembly of Mir. The original plan called for successive placement of all four modules and the eventual docking of the Buran shuttle to Kristall, all of which should have occurred by 1990. Instead of being launched the two remaining modules were placed in storage at the Khrunichev Works and not until the merging of the American and Russian programmes were they finally readied for launch.

Each arriving module requires one of these drogue cone receptacles at the receiving forward axial port of Mir, (-X), and also at its final resting port. Prior to Kristall's initial docking the resident Mir crew moved the drogue cone from the upper +Y port to the lower -Y port for the

later repositioning of the module.

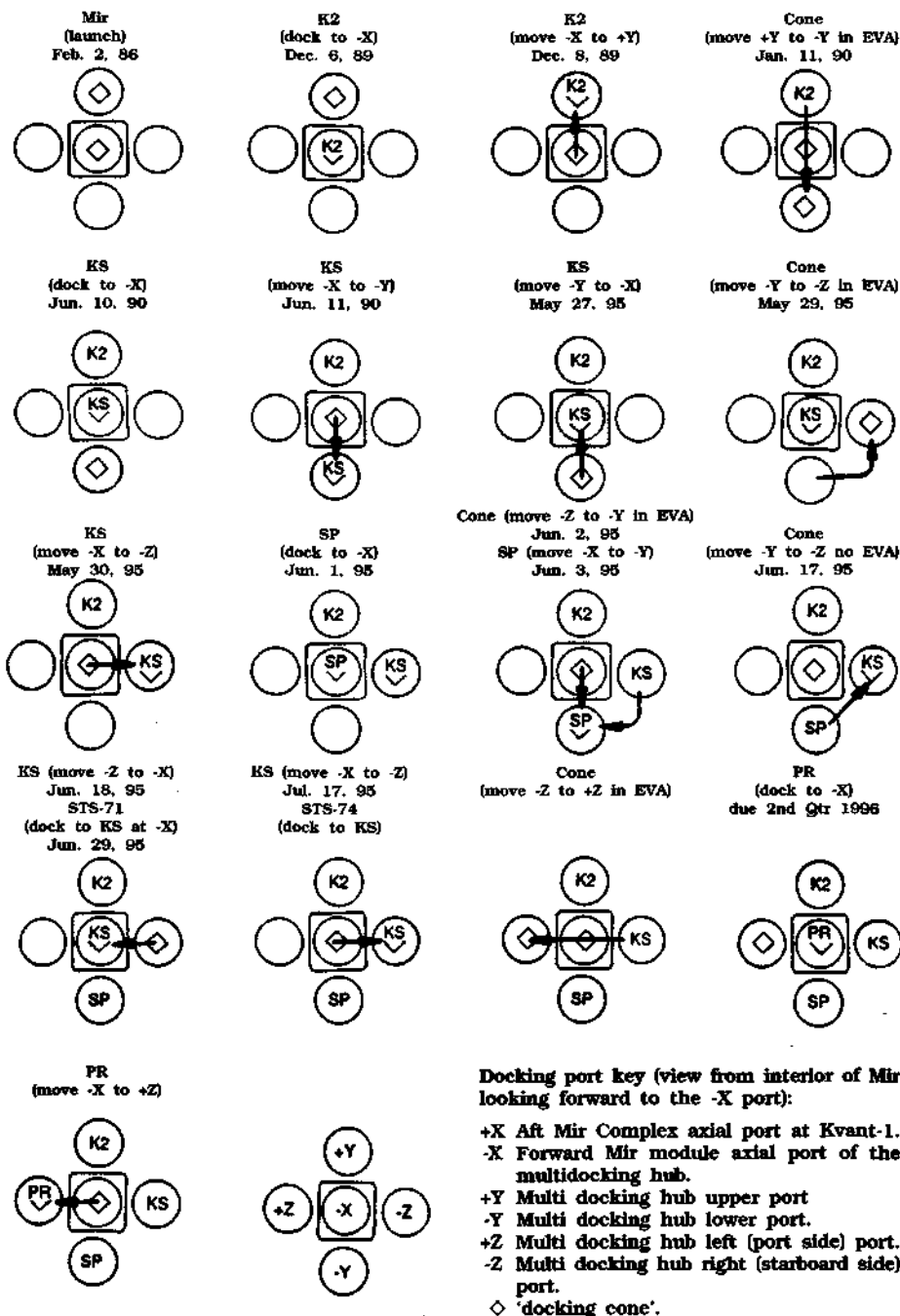
This movement required the resident crew to place the drogue docking cone in the -Y port during an EVA, since the -Y port previously was sealed using a hinged flat door. The other two ports, +Z and -Z, are also sealed with hinged flat doors. After opening the door and removing it, the forward docking hub is exposed to space while the cone is secured into position. Once the receptacle is in position the forward hub can be repressurised,

concluding the EVA.

The chart below shows how and when each of these movements has been or is to be made during the docking and subsequent repositioning of each module.

Prior to the Spektr docking and over the course of several EVAs, Kristall's solar arrays were retracted and the port side array was removed and transferred to a pre-prepared site at Kvant-1 [1]. The other array will be moved later. The Kristall was then repositioned to the -X

Chart showing docking port locations of Mir modules.



New Module for Mir

port, and then to the starboard side -Z port. Between these movements an EVA was required to move the docking cone from the -Y port to the -Z port. Spekt's final resting place is the -Y port, the former Kristall position. Kristall was originally placed in that position to balance the mass handling of the station until the Spekt could be readied for launch.

Spekt followed the standard arrival and transfer procedure conducted by Kvant-2 and Kristall, with an EVA being conducted following its arrival to move the docking cone for the craft's repositioning from the -X port to the -Y port.

Due to Mir solar array clearance concerns over the STS-71 docking, Kristall was repositioned to the forward -X port during those joint activities. Shortly following the shuttle undocking, Kristall was repositioned to the -Z port once again.

The STS-74 mission to Mir will place a new docking tunnel extension adapter on the end of Kristall, to provide solar array clearance and avoid the need to move that module for each future docking.

The last module, Priroda, is scheduled to dock with Mir in the second quarter of 1996 and will be placed in its position at the port side, +Z port, of the multiple docking hub. Just prior to or immediately following this docking, one final 'cone moving' EVA will be required. This will conclude the assembly of the Mir complex.

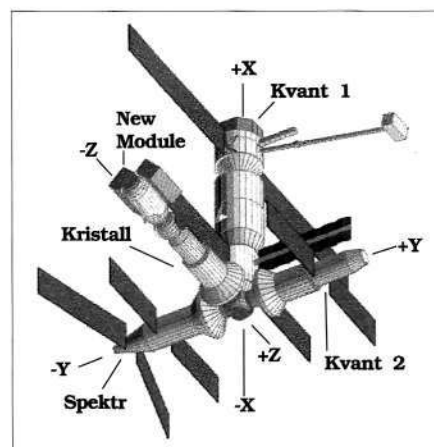
Author's note: if any reader finds fault with this procedure of assembly and 'cone' movement, please write to me, care of this magazine.

Reference

1. N. Kidger, *Spaceflight*, July 1995, pp.221-225.

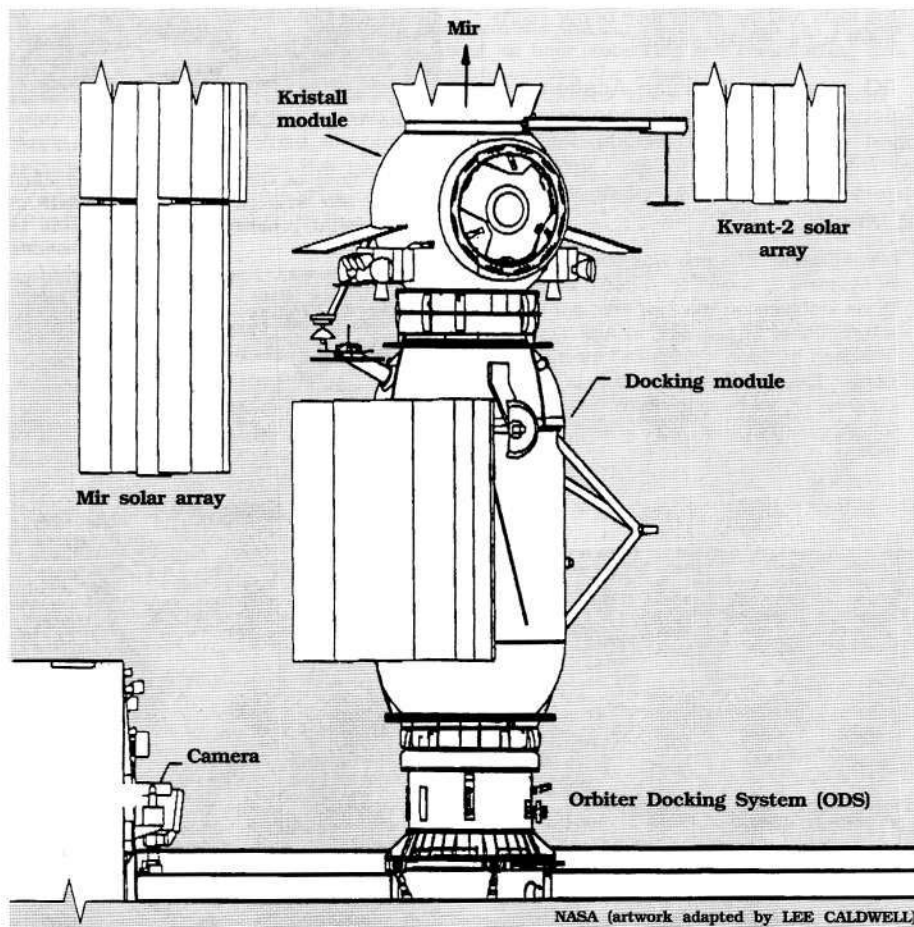
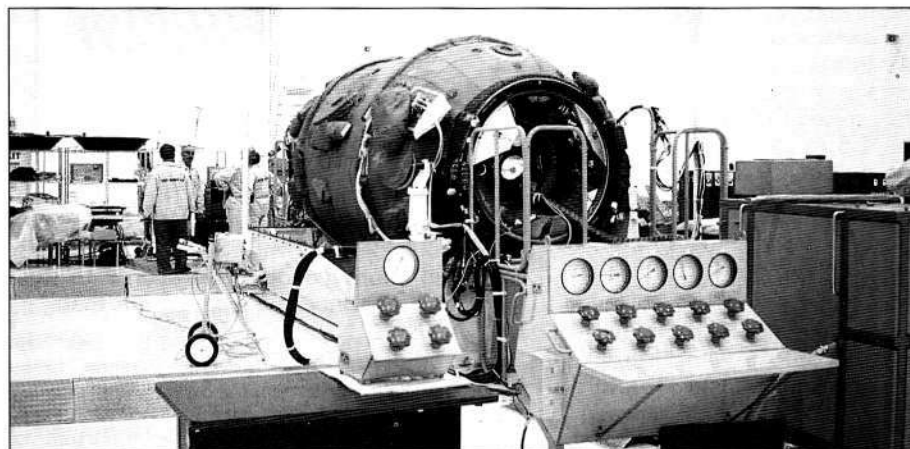
The recent STS-71 docking was a complete success but it has been deemed impractical to go through the task of moving the Kristall module to the axial Mir docking port each time a shuttle is to dock. Also, the manipulator on Kristall which actually moves the module would reach its design lifetime before the six planned shuttle dockings were complete, so the Russians devised a new plan for future shuttle dockings.

A new cylindrical module is to be added to Mir that is about 5 m long with an APAS-89 androgynous docking port on each end. The module is to be carried into orbit by STS-74 and docked on to the orbiter's docking module using the shut-



The Docking Module seen from the end with the Kristall docking port and surrounded by Russian ground support equipment. The Shuttle RMS grapple will be attached to the round mounting point just above the docking port.

DENNIS NEWKIRK



NASA (artwork adapted by LEE CALDWELL)

tle's Remote Manipulator system. Once in place on the end of the docking module, the shuttle would dock the module to Kristall's axial APAS-89 docking port. The extra module will provide sufficient clearance to ensure that there will be no problems of a shuttle collision with parts of Mir during docking. It will also carry two new solar arrays to be added on to Mir's existing modules.

On 7 June 1995, the module and equipment totalling 45 tons arrived at the Kennedy Space Center in an Antonov An-124 along with 60 RSC Energiya employees. Other pieces of equipment were also delivered including equipment for use in training at the Johnson Space Center, and a high fidelity docking module model to be used in a water tank EVA trainer.

The docking module became the first piece of hardware to be processed in the Space Station Processing Facility. The high bay had to be rushed into service to accommodate the docking module and its final integration and testing. Almost all of the test instrumentation and equipment for the module was brought in by the Russians. NASA only had to provide consumables like helium, nitrogen, conditioned air, pressurised air, power and 60 to 50 Hz power converters to support the Russian equipment.

After being formally handed over to NASA it will move to the Orbiter Processing Facility for installation into Atlantis' cargo bay for launch on STS-74.

DENNIS NEWKIRK

MIRAS OK After EVA Suspense

French-Belgian Spectrometer is Installed by Cosmonauts on Platform Outside Spektr Module

On 21 July cosmonauts Anatoli Solovyev and Nikolai Budarin carried out their third EVA within one week as reported in *Spaceflight*, September 1995, p.311. More details about the EVA can now be given. Its main purpose was to deploy the 235 kg French-Belgian MIRAS (Mir Infra-Red Atmosphere Spectrometer) instrument for infrared observations of the Earth's atmosphere during solar occultations. These observations are to be made for almost one year and will be used to monitor the composition of the atmosphere by infrared absorption spectrometry, to establish the concentration profiles of at least 15 minor gas constituents from 20 km to 120 km altitude.

During the EVA, the two cosmonauts had to transport MIRAS from the airlock of the Kvant 2 module to the Spektr module at the opposite extremity of the Mir station. On 21 July they exited from Kvant 2 and attached the 2.5 m long MIRAS instrument to the end of the 14 m Strela telescopic boom which is able to move a load of up to 700 kg from one side of the station to the other. While Solovyev kept close to MIRAS, Budarin manoeuvred Strela above Mir's core element to the Spektr module. Solovyev and Budarin installed MIRAS with three clamps on an external mobile structure at the conical end of Spektr between the two arrays of solar panels and successfully fixed the five connectors required for power and communications.

The work to install MIRAS was terminated after less than two hours of EVA but TSUP controllers at Kaliningrad were unable to receive data to indicate that MIRAS was alive and well. Finally, they discovered a failure in Spektr's system for transmitting data to the ground. After 5 hours and 50 minutes of EVA, Solovyev and Budarin checked the communications link inside Spektr and found that a connection had not been correctly made. They rectified the problem and after five hours of a great suspense, MIRAS transmitted its first signals.

A "First" in Cooperation with Moscow

Measurements on up to 700 solar occultations are planned for the spectrometer during the period of one year. The placement of MIRAS on the Mir station represents the culmination of a five-year effort initiated by Baron Marcel Ackerman, Director General of the Belgian Institute for Space Aeronomy with IKI (Institute of Cosmic Research) at Moscow. In the agreement signed between Moscow and Brussels, MIRAS was designed for use in 1995 on the core module of the Mir 2 station. Political changes, budgetary constraints and substantial delays forced IKI and RKK Energiya to locate

BY THEO PIRARD
Belgium

the experiment on the Spektr module developed with NASA funding.

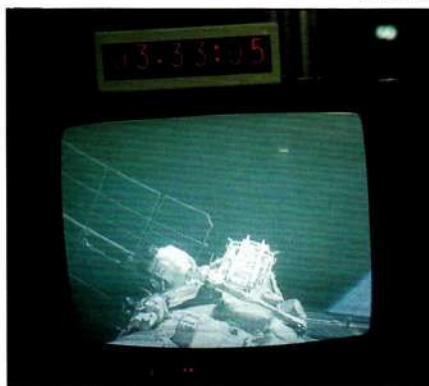
For Robert Hennecart, Head of MIRAS Project at Alcatel-ETCA, the development of a non-Russian instrument to be installed by cosmonauts outside Mir represented a real "first" in international cooperation with Russia in space. He pointed out that:

"Our team of engineers and technicians were allowed to work for many weeks with Russian people inside the previously secret KIS (Spacecraft Integration Facility) at the Energiya headquarters of Kaliningrad. We participated directly in the tests and the integration of our instrument in the Spektr module."

IKI scientists (Russian Academy of Sciences) would like to continue the cooperation with the Belgian Institute for Space Aeronomy. Igor M. Kizenkov, Deputy Head of Department at IKI states:

"Flight model 2, which was used for tests at Moscow, is available. It could be ready to be installed on the first element of the International Space Station Alpha, which is scheduled for launch in late 1997 or early 1998, but Belgian scientists and industries would have to obtain the funding for this continuation with the Alpha station."

The MIRAS platform on the Spektr module.
Th.P./SIC



The launch of the Spektr module by a Proton rocket from Baikonur on 20 May 1995.
NASA/Th.P./SIC



At the TSUP at Kaliningrad on the 21 July.
Th.P./SIC

On the floor of the Spektr module docked to the Mir station is seen the MIRAS experimental package which was made in Belgium.
NASA/Th.P./SIC



Galileo Approaches Jupiter

The Galileo spacecraft is nearing the end of its long (six year) trek from Earth to Jupiter. On 7 December 1995, the Probe will enter the Jovian atmosphere, and the Orbiter will scoop up data from the Probe and place itself in orbit about the giant planet. The cruise has been scientifically productive with three planetary flybys, two asteroid encounters, flybys of Earth's Moon, and observations of a cometary impact on Jupiter. A summary is given below.

The explosion of the space shuttle Challenger in January 1986 delayed the launch of Galileo well beyond the planned time in May of that year, in fact, until 18 October 1989. However, even more time was lost with respect to arrival at Jupiter because the powerful Centaur rocket, following a far-reaching safety review subsequent to Challenger, was banned for use as an upper stage for shuttle. After examining several options, some of which were reported in these pages, the Galileo project abandoned the idea of a direct flight to Jupiter (which takes almost three years) and opted for a series of three planetary gravity assists.

The purpose of the gravity assists was to supplement the chemical energy of the Inertial Upper Stage (IUS), which NASA substituted for the Centaur, in order to have enough "gazingas" to get to Jupiter. (Forgive my lapse into technical jargon.)

The first gravity assist was to come from a close passage by Venus, which, being closer to the Sun than Earth, required that additional thermal protection be supplied to the spacecraft prior to launch. The second and third gravity assists were to come from close encounters with Earth. Hence, the name "VEEGA" for "Venus-Earth-Earth Gravity Assist" is applied to this trajectory.

The Galileo Project has put the years of cruise to good use in assembling a surprisingly wide variety of scientific accomplishments. In addition, the cruise phase has been used to characterize the spacecraft and calibrate instruments in order to prepare for the principal job at Jupiter. The incremental increase in heliocentric speed at Venus (in February 1990) was 2.2 km/sec (about 6% of the spacecraft's total speed) as the vehicle flew to within 16,000 km of the second planet from the Sun.

Some scientific observations were accomplished, e.g., 81 images were made of Venus, a body permanently covered by clouds. The imaging was complementary to the data type obtained from NASA's recent Magellan mission, which utilized a synthetic-aperture radar (SAR) to pierce the cloud deck and image the surface.

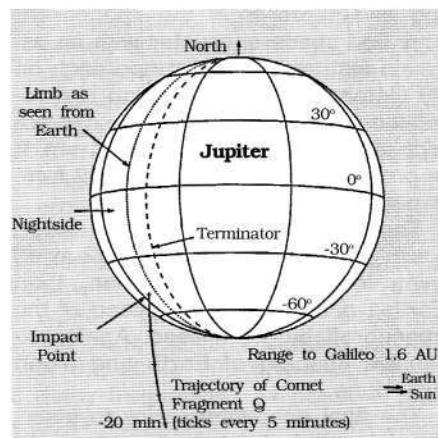
BY DR W.I. McLAUGHLIN
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Later in the year, the Galileo spacecraft looped back to Earth and acquired another 5.2 km/sec by passing above the surface at an altitude of 960 km, within 8 km of the targeted altitude.

At this "Earth-1" encounter, both Earth and Moon were observed. Lunar imaging, in the visible and infrared, included studies of the composition of farside (away from Earth's view) crust, the structure of the Mare Orientale impact basin, unexplored regions around the lunar south pole, and improved mapping, i.e., better coordinates for lunar topographic features.

The Galileo Probe goes through final preparations at Hughes Space and Communications Company in 1989 before being shipped to NASA for integration with the Galileo orbiter spacecraft. Here, Hughes technicians prepare to verify the centre of gravity of the 747-pound probe, which will experience large decelerations on encountering the Jovian atmosphere. After the fiery entry, an internal descent module carrying scientific instruments will parachute through the atmosphere for about an hour, collecting and transmitting data to the orbiter circling the planet.

HUGHES SPACE AND COMMUNICATIONS COMPANY



View of Jupiter from the Galileo spacecraft of the impact of Comet Shoemaker-Levy 9. The trajectory of comet Fragment Q is shown. The range is 240 million kilometers.

NASA/JPL

tures. In addition to the imaging subsystem, the Near Infrared Mapping Spectrometer (NIMS) was used and the exercise not only yielded scientific data but also calibrated NIMS for Jupiter.

The post-launch smooth flow of successes received a rude jar when in April 1991 the spacecraft's 4.8m high-gain antenna failed to unfurl fully when commanded. It had been stowed since launch. The flight team tried for almost two years to shake the antenna loose and force it to deploy but to no avail.

The effect of this failure has been to restrict communications to the low-gain antenna, lowering the rate at which data can be sent to Earth from a maximum of 134 kilobits per second to around 160 bits per second: a reduction of three orders of magnitude. The principal impact of the loss of so much downlink capability is to limit the number of pictures that can be returned to Earth. Nonetheless, mission planners estimate that approximately 70% of mission objectives at Jupiter will be met, and about 1500 images of the Jovian system will be obtained.

Two primary countermeasures were taken to alleviate the problem: (1) increase the effectiveness of the Deep Space Network to capture data, and (2) make fewer bits do the work of more by compressing onboard (with the spacecraft's computer) data prior to transmission to Earth.

While, in parallel, the mission at Jupiter was being redesigned to cope with the reduced data rate, the flight team continued to shepherd the spacecraft through the inner Solar System.

Following Earth-1, asteroid Gaspra was the next targeted en-

counter for Galileo. The navigational challenge was met by a combination of Earth-based radio tracking of the spacecraft, Earth-based optical tracking of the asteroid, and optical tracking of Gaspra from the spacecraft. This first space encounter with an asteroid featured a closest approach on 29 October 1991 at 1600 km and revealed a pock-marked, irregular object of dimensions 19 x 12 x 11 km. It is probably a collisional fragment from a parent body.

The third and final gravity assist, Earth-2, was in December 1992 at an even lower altitude, 303 km, than Earth-1 and boosted the speed of the spacecraft by 3.7 km/sec. Again, extensive imaging of Earth and Moon was done.

The final encounter, prior to insertion into orbit about Jupiter, was with asteroid Ida, twice the size of Gaspra, at a range of 2400 km on 28 August 1993. Considerable surprise was occasioned when Ida was found to have a small companion about 100 km from its centre! This object, dubbed "Dactyl," is only about 1.5 km in diameter. Ida-Dactyl provides a cameo example of what is best about space exploration: the surprises. A fragmented comet was discovered in March 1993 by Gene and Carolyn Shoemaker and David Levy. Since this comet was the ninth discovered by the team, it was named "Shoemaker-Levy 9" (SL-9). Astronomers were astonished to find that SL-9 would impact Jupiter in July 1994: celestial collisions between good-sized objects are rare events. Galileo would be positioned to view the impacts directly, a distinction largely denied to Earth-based telescopes. Galileo was approximately 240 million km from Jupiter at the time of the impacts. All told, 23 fragments splashed into the Jovian atmosphere between 16 July and 22 July. Those impacts observed by Galileo began with a rapid rise in brightness (achieving about 10% of the brightness of Jupiter) then flattened in intensity before slowly declining. In ultraviolet light, a typical impact lasted for less than 10 seconds but extended 90 seconds or more in the infrared. Splashbacks were observed 5 or 6 minutes later. In order to facilitate the search for the most interesting images to transmit first, ground controllers had the spacecraft send back "jail bar" (partial) images. The entire process of returning the multi-instrument set of data on SL-9 extended over a period of six months. The final picture of the complex interactions between the high-speed fragments and the Jovian atmosphere is still being assembled. Several surprises, such as some Earth-based observations occur-

ring at nearly the same time as those seen by Galileo, have yielded new insights into the structure of the atmosphere of Jupiter. This new knowledge will, in turn, enable Galileo's studies of Jupiter's atmosphere to be even more fruitful than originally anticipated once it goes into orbit about the planet*.

On 13 July 1995, the spin-stabilized Probe was cut loose from the Orbiter and pushed gently away to allow it to proceed on a trajectory which will take it into the Jovian atmosphere on 7 December for a parachute descent. The Probe, as it cruises to Jupiter, will not communicate with the Orbiter until December. A timer will initiate pre-entry science (6 hours prior to entry) while "g-switches" will be used for post-entry events.

The Orbiter, on essentially the same trajectory as the Probe immediately after separation, had to be deflected from its course in order to avoid entering, along with the Probe, into the atmosphere of Jupiter.

The Orbiter deflection manoeuvre (ODM) was accomplished on 27 July using the 400-Newton main engine of the spacecraft. Any significant propulsive event, such as launch or firing of a main engine, is treated by engineering teams with great respect.

The ODM itself was preceded by testing propulsion-system valves and then conducting a two-second test firing of the main engine. After six years in space, all elements functioned well. (This engine actually had not been fired since 1984.) The ODM required a main-engine burn of 308.1 seconds, which resulted in an Orbiter speed change of about 60 m/sec. The performance of the propulsion unit was

well within specifications and valuable data on engine characteristics were gained. (One valve was found to be stuck open, not necessarily as a result of the ODM, but it is not thought that this will affect the mission.) These data will be used to plan the burn sequence, which will require firing the main engine for 47 minutes in order to insert the Orbiter into a trajectory about Jupiter for its two-year tour of the gas giant, its complement of satellites, rings, and magnetosphere.

In late July of 1995, Galileo encountered the largest interplanetary dust storm ever measured, detecting up to 20,000 microscopic dust particles per day. (Normal would be one particle every day.) Calculations show that the measured impact rate implies that approximately 15 million particles per day struck the spacecraft during the storm's peak. The dust originates from somewhere in the Jovian system (perhaps from a volcano on the satellite Io, or from SL-9, or from the Jovian rings).

The harvest from the cruise phase of Galileo, in retrospect, is seen to contain items of considerable value, and, most importantly, judicious investments of time and acceleration have placed the spacecraft within reach of its goal: the system of mighty Jupiter. With flybys of up to 350 times closer than Voyager, Galileo promises to increase our knowledge and excite our imaginations.

If you want to keep up with the mission electronically, you can access the Galileo homepage at <http://www.jpl.nasa.gov/galileo> on the World Wide Web and access <http://quest.arc.nasa.gov/jupiter.html> for the "Galileo from Jupiter" homepage.

Science from the Moon

After the heights of achievement of the Apollo missions, the Moon has fallen into disuse. However, there are stirrings of interest, once more, in exploring and using the Moon. Several lunar conferences have been held in the last decade, and from these a consensus is emerging as to what sets of astrophysical observations the Moon, as an observing platform, is best suited. In addition, the Galileo spacecraft in 1990 and 1992 conducted a series of observations of the Moon, as did the Clementine mission in 1994. Last year, I chaired the Lunar Observatory Steering Group (LOSG) for NASA, and some of the conclusions we reached will be examined here*.

Recognizing NASA's very austere budget climate, the LOSG concentrated on identifying those scientific opportunities which might be grasped without large expenditures of funds. No specific dollar cap was set because we were not carrying the analysis to the mission and system design stage, where costing would be possible, but something like NASA's

Discovery-class missions were envisaged (at \$150 M). A robotically-emplaced and operated observatory on the Moon was the primary focus.

A lunar observatory would be valuable, of course, for astrophysical observations since the Moon has only a tenuous atmosphere. But the Moon is also geometrically situated to favor synoptic views of the Earth's magnetosphere, so Earth science as well as astrophysics could benefit from a lunar facility.

For this first cut, the LOSG looked at five areas of scientific investigation that might be carried out in a low-cost mode from the Moon.

* A summary of ground- and space-based observations of the SL-9 event is contained in the October 1995 issue of *Sky & Telescope* (pp. 18-26).

See also the paper "The Moon as an Observational Platform for Astronomy—Long Term Strategy for a Return to the Moon", R. S. Saunders, C.B. Pilcher, M.S. Kaplan, W.I. McLaughlin, presented at the IAF Congress in October 1995 in Oslo: IAF-95-Q.2.05.

An Astrophysical Low-Frequency Array (ALFA)

This would be a radio array on the Moon's surface covering a region of about 100 km in diameter with 15-20 scientific packages. Each (identical) package would contain a wire dipole antenna of about 10 m, end-to-end, operating in the range of the electromagnetic spectrum between about 30 kHz to 30 MHz. Much of this span is blocked by the Earth's atmosphere, and, in fact, it is one of the last regions of the spectrum which remains to be explored.

It would be best to place the ALFA array on the lunar far side in order to obtain shielding from terrestrial radio sources, but this would increase the expense since a relay satellite would be needed to pipe the data back to Earth. The LOSG concluded that operation on the lunar near side would still be scientifically valuable. Another scheme to hold down the cost was the idea of hard-landing the packages.

Lunar Ultraviolet Telescope Experiment (LUTE)

The Earth's atmosphere blocks ultraviolet (UV), and a 1-meter class telescope on the lunar surface would take advantage of the airless state of that body. The instrument would conduct a high resolution, wide-area survey in the ultraviolet and far ultraviolet portions of the electromagnetic spectrum.

Scientific objectives include: studies of the morphology and evolution of galaxies; examination of regions of star formation (identified by the presence of hot, young UV-bright stars); active galactic nuclei and quasars; and the structure of the UV background.

A possible way to implement LUTE is through the deployment of two stand-alone instruments. One would be a transit telescope (with, by definition, limited pointing capability), and the other would be a telescope with conventional pointing capability. The transit telescope would be used to conduct a deep UV-survey, picking up faint, distant objects.

Lunar Infrared Telescope

Just as one benefits in the UV by observing in the near vacuum of space, infrared (IR) observations are facilitated when filtering by Earth's atmosphere is removed. Scientific objectives include the study of low-mass stars and, possibly, brown dwarfs, plus newly-forming stars. The investigation of the birth and evolution of galaxies and understanding ultra-luminous galaxies are also attractive areas for research.

A 1-meter class telescope operating in the 1-10 micron wavelength region is envisaged because it would only need to be cooled to about 70° K in order to be limited in sensitivity only



View of the Moon's north pole taken by Galileo on December 7, 1992. Much of the region adjoining the illuminated limb is visible from Earth. This view is a mosaic assembled from 18 images taken through a green filter. In addition to its interest as a geophysical object, the Moon will probably become a platform for astrophysical and even Earth-pointed scientific observations.

NASA/JPL

by the natural sky brightness, and this temperature can be achieved with cryogenic coolers of modest mass or even by passive cooling.

Optical Interferometry

Optical interferometry is a technique that has been growing rapidly in capability at installations on Earth. For example, a series of interferometers has been constructed and used on Mt. Wilson, near Los Angeles, by Dr. Michael Shao of JPL, and a more advanced facility is being assembled by Shao and colleagues on Palomar mountain, near San Diego. NASA has plans to exploit space-based interferometry early in the next century.

Interferometers, with their ability to measure stellar positions very accurately and to provide high resolution images, are important elements in plans for astrophysical research (establishing distance scales, analyzing the dynamics of star clusters, etc.) and in the detection and imaging of extra-solar planets. These instruments are attractive from an engineering perspective because of their low mass, compared to a filled-aperture telescope with the same resolution. Of course, one gives up photons in this comparison case. But, more generally, an interferometer allows one to optimize the balance between collecting area and resolving power and not just have to accept the particular combination that happens to result from the geometry of the circle.

Even a two-node optical interferometer, with 10 cm telescopes and a total instrument mass of 75 kg, would make a useful start toward the goal of establishing a larger network with many optical nodes.

Magnetospheric Imaging

It might be thought that Earth's magnetosphere—that electromagnetic cocoon which enwraps us—would best be investigated by Earth-orbiting satellites, and indeed, they are extremely useful tools for this purpose, starting with Explorer I in 1958. However, seizing the high ground has its advantages.

There are a number of synoptic magnetospheric studies which can profitably be conducted from the lunar surface; the so-called auroral kilometric radiation (AKR) is the most powerful (but highly variable) of the types of naturally occurring kilometric radiation. Viewing the AKR in the 20 to 200 kHz range in as many frequencies as possible (perhaps 20) in time intervals of about one second would give a good picture of the hours-long storm periods.

The preceding very brief summaries of some scientific candidates by no means exhaust the possibilities*. In fact, one of the conclusions of the LOSG was that canvassing should continually be done for high-value science that can be carried out on the cheap.

Unless one is just looking for the best science that can be done from the Moon, the advantages of carrying out an investigation by free-flying spacecraft must always be considered, just as one considers Earth-based capabilities before proposing a space mission for astrophysical purposes.

The obvious fact that the Moon is not space makes it an attractive location for storing assets such as structures, electronics, power-generating devices, communications facilities, etc., and expecting to be able rather easily to connect them to multiple scientific experiments, contemporary or in a temporal series. The Moon might be said, in this sense, to have a memory, and, therefore, the proper comparison might be a set of free flyers versus a set of lunar experiments. Of course, the lunar gravity well and the destructive effects of thermal cycles and dust work in the other direction. Nevertheless, lunar memory is a mark which distinguishes it from free flyers in the competition for venue.

As of now, there is no NASA plan to return to the Moon (other than the occasional mission such as Lunar Prospector). But ESA has indicated interest in venturing into this arena - see *International Lunar Workshop: Towards a World Strategy for the Exploration and Utilization of Our Natural Satellite*, esa sp-1170, November 1994 - and one senses that budgets more than rationale must be worked in order to see an ecumenical lunar effort come to pass.

*See, for example, *Astrophysics from the Moon*, AIP Conference Proceedings 207, ed. by M.J. Mumma and H.J. Smith, American Institute of Physics, New York, 1990.)

What About Mercury?

Although the planet Mercury has been known since antiquity, telescopes from Earth gave no indication of its surface details. The exploration of the Solar System using artificial space probes over the last twenty or so years has added enormously to our knowledge of the planets and satellites but unfortunately has hardly involved Mercury at all. Its time of glory was short: it came in 1974/5 with three flybys by the Mariner 10 spacecraft (29 March and 21 September 1974 and then 16 March 1975). Nevertheless, important, though restricted, information was obtained and we know considerably more about Mercury now than we knew before*.

Of especial significance to us here were a photographic reconnaissance of the surface and an exploration of the magnetic conditions. The latter was interesting because it explored the effect of the solar wind interacting with the planet nearest the source (that is the Sun). The earlier belief that the sidereal and synoptic rotation periods are the same was found not to be the case. The planet rotates about its axis in 58.65 days and around the Sun in 87.969 days making the ratio of the periods almost exactly 3:2.

This particular ratio brings two points of the planet surface always under the Sun during its orbit, producing two fixed hot "poles" 180° longitude apart. The inclination of the equator to the orbit was found to be about 2°.

The quality of the information obtained was not of the standard developed subsequently as experience was gained in exploring the wider Solar System. The photographic resolution of the surface was not good (a kilometre or so) in relation to that achieved later (a few metres in some cases) with the major planets and satellites. Again, the spacecraft passed Mercury at considerable speed. The trajectories of the flybys were such that only about 45 % of the surface could be surveyed and this is what is available to us now. The dangers of partial photographic surveys are well known and were clearly shown by the differences in the surface conditions of Mars deduced from the Mariner 4 flyby encounter on 14 July 1965 and the Mariner 9 long life orbiter of 1971. Nevertheless, important information about Mercury has been deduced from the Mariner 10 mission which has given a tantalising insight to the planet, but we need to know more. What we know now and what we would like to know are the subject of this article.

Broad Features

The Mercury orbit has a mean ra-

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dius of 0.387 A.U. (1 A.U. = 149.6 million km) giving an orbital speed of 47.89 km/s with an inclination to the ecliptic of 7°.004. The precession of the perihelion of the orbit arises largely from the disturbing effects of other planets but 43 sec of arc per century remains unaccounted for this way. Accounting for this residue proved beyond the Newtonian theory of gravitation within reasonable assumptions but was successfully accounted for in 1917 by the then new theory of general relativity. Another moment of glory for Mercury.

Mercury is a small planet (only Pluto is smaller) having a radius of 2,439 km. This is only a factor 1.4 greater than that of the Moon. Its accepted mass (derived originally from analyses of the perturbation of its orbit) is 3.303×10^{22} kg, which is nearly 4.5 times the lunar value. Here is one of the interesting features of Mercury: its mean density is 5.430 kg/m³. This makes it the second most dense body in the Solar System (after the Earth with the mean density 5.520 kg/m³) even though only Pluto, with a mean density of 2.030 kg/m³, is less massive.

The photographs of the Mercury surface show a barren and highly cratered terrain with no current activity, entirely reminiscent of the lunar surface. Indeed, the two surfaces appear almost indistinguishable except to the expert. Plots of the percentage of the surfaces covered by craters bear a strong resemblance to each other. There are, however, differences of detail. The Mercury crater diameters show a rather sharp peak at 100 km whereas the lunar crater sizes are more well spread between diameters of 20 - 200 km. Again, the density of craters on the two surfaces differ in detail. Considering craters with diameters in the range 5 - 10 km per million square kilometres of surface, this

peaks rather broadly about the value 240 km for Mercury but more sharply peaks instead about the value 80 km for the Moon.

The degree of overlapping of craters allows a relative chronology for the surface to be established. The lunar material returned to Earth by the Apollo missions has allowed an absolute chronology to be established for the Moon. A comparison between the lunar and Mercury crater details then implies an absolute chronology for Mercury. Such a comparison suggests the nomenclature developed for the Moon (for instance the word basin for a very large crater) will be useful for Mercury as well. Apparently the smooth plains on Mercury are a very early formation, probably as much as 3,900 million years old. It seems safe to say that (like the Moon but unlike Mars, Venus and Earth) the present Mercury surface is very old with an early history of heavy cratering which is still preserved. The earliest cratering on Mercury appears to have been several times greater than on the Moon, but the later cratering rates were probably comparable.

The surface features of Mercury can be divided into five broad divisions which portray a general time sequence of events. Four of the features are very general: heavily cratered terrain; intercrater plains; smooth plains; and young craters. There is also some evidence of contraction faults as if the early surface has shrunk by a few kilometres (presumably due to a cooling of the planet). The fifth broad division is the major topological feature dominating everything we have seen so far. This is the Caloris basin, which is probably of the same general age as the lunar Nectaris basin. It lies near one of the "hot poles" (hence the name Caloris) and spreads over a diameter of some 1,500 km. An unusual hilly region at the anti-podal point on the surface could well be the result of the focusing of seismic energy released by the collision with the substantial planetesimal which formed the basin. If this is so, it caused great interior structural damage to the planet. One is reminded of the large crater on Mimas (also in the equatorial region) which shows a similar anti-podal effect. In general terms the Mercury surface gives every appearance of an ancient surface that was perhaps once molten but which cooled relatively rapidly and which has seen little activity over the last 3,000 million years at least. One is tempted to expect a thick crust encasing a rather cold solid interior. What activity accompanied the formation and early history of the planet soon dissipated leaving a dead world.

Atmosphere

Like the Moon, Mercury does not possess an atmosphere now in the

*This article is based on the evening lecture given by the author to the British Interplanetary Society on 8 March 1995.

normal sense but it does have an extremely thin and stable gaseous covering with a surface pressure of about 10^{-15} bar. This has helium, sodium and oxygen as the principle components although some hydrogen and potassium have been detected. These traces must result from impact with the solar wind although a degree of outgassing cannot be ruled out. The helium content could come, in part at least, from the products of any radioactivity in the near surface rocks. The helium pressure on Mercury is about 4×10^{-16} bar which compares with about 5×10^{-6} bar for the Earth. Any initial atmosphere can be expected to have been lost over the history of this small planet partly due to the low surface gravity and partly due to the high surface temperature (about 440K). Clues to what the early atmosphere could have been may still be preserved in surface rocks. It is not clear whether the early atmospheres of the terrestrial planets outgassed from inside (through volcanic activity and seepage through the rocks) or resulted from collisions with substantial planetesimals or comets. Probably both sources contributed.

Magnetism

With an apparently cold and dead interior, Mercury would not be expected to possess an intrinsic magnetic field on the basis of the current thinking of the formation of intrinsic planetary magnetic fields.

A dipole field signature is taken as showing the source of the field to be active now since remnant magnetisation has a more complex signature. The intrinsic field of a planet is thought to arise from the motions of an electrically conducting fluid contained in a region inside the planet through the so-called dynamo mechanism. For the Earth this region is the liquid ferrous outer core; for Jupiter and Saturn it lies in the metallic hydrogen/helium regions deep in the mantles above the cores; for Uranus and Neptune it is most likely in the core/mantle boundary regions.

The source will produce a complex magnetic field with many polar components, the dipole component being only one. What is seen at the surface is determined by the depth of the source below the surface. The intervening material screens the field. The dipole component is the least attenuated with distance so a strong dipole configuration at the surface implies a source deep in the planet. This is the case for the Earth where the dipole component accounts for some 80% of the total surface field. The quadrupole moment is strong for Jupiter implying a source nearer the surface. Observation of the details of the magnetic field provides real constraints on the conditions that can be assumed inside.

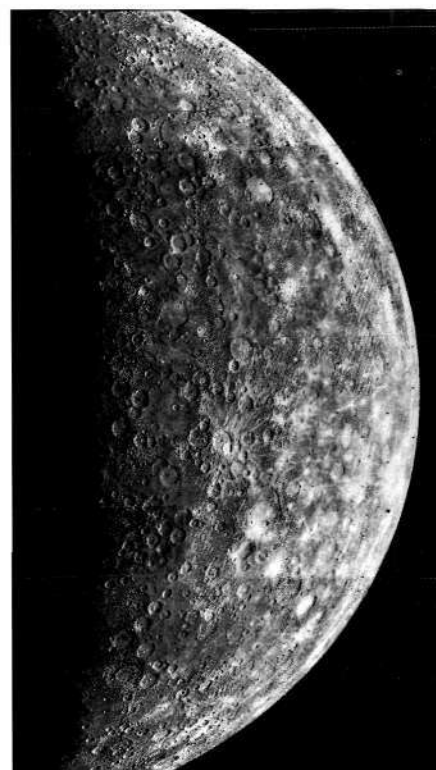
Observations of the behaviour of the solar wind in the vicinity of the

Mercury surface showed that Mercury does indeed have a small intrinsic dipole magnetic field now. The equatorial field strength is estimated as 2×10^{-3} gauss with a dipole moment of about 3×10^{22} gauss cm². The magnetic axis is pointed anti-parallel to the rotation axis making an angle of less than 10° between the two axes: this magnetic arrangement is the same as for the Earth now. It is not known what proportion of the whole field is dipolar, so it is not known whether the dipole field is the major or minor component. This means that we have no indications yet as to how deep the source may be.

It is clear that Mercury presents a magnetic problem. The surface characteristics are consistent with an internally inactive planet with a substantial material rigidity inside. The internal pressure, it is true, will be sufficient to cause a certain creep of the material and so to provide a spherical surface figure but rapid motions able to produce a magnetic field are hard to understand. On the other hand, the high mean density suggests an abundance of iron, which is a good electrical conductor. The small but non-zero angle between the magnetic and rotation axes is also a good sign. A theorem was discovered by T.G. Cowling in the 1930s which limits the symmetry of a magnetic field resulting from a symmetric fluid motion. Rotation will affect the motion but any close coincidence between the rotation and magnetic axes is forbidden by the theorem. The angle between the axes for the Earth of some 11.5° is accepted as fulfilling the theorem and the Mercury angle would present no difficulties in this connection. The discovery that Saturn has an angle that is indistinguishable from zero is still not understood.

The similarity between the Moon and Mercury makes the discovery of remnant magnetism in lunar rocks relevant here. The Moon is rather smaller than Mercury but seems to have once had a magnetic dynamo that is not active now. Details of the present Mercury field could prove interesting for these studies.

The anti-parallel field alignment for Mercury is interesting. It is known, of course, from geological observations that the alignment for the Earth has changed quasi-periodically many times over geological time so a parallel or anti-parallel alignment should have little significance. This is readily accounted for in general terms by the dynamo mechanism. But both Mercury and Earth (terrestrial planets) have an anti-parallel alignment now whereas all the major planets have a parallel alignment. Unfortunately, theory is still not able to draw any significance from this comparison. It is realised from these comments that details of the field for Mercury, as a small planet, could have value in the general approach to an understanding of planetary magnetism.



This mosaic photo of the planet Mercury was compiled from 18 separate photographs taken in 1974 by the Boeing-built Mariner 10 spacecraft. Mariner 10 is the only spacecraft to visit Mercury and it provided scientists with mapping imagery of almost half of the Mercurian surface. Now, over 20 years later, NASA is evaluating, as part of its Discovery program of low-cost missions, a proposal by JPL to orbit Mercury and remote sense its surface atmosphere and magnetosphere. NASA

Internal Structure

What, then, would we expect the Mercury interior to be like? Some indication comes from the general theory of planetary interiors. The mechanical equilibrium of a planetary body is known to result from the balance of gravity, acting to compress the inner material, and the resistance of this material to undue compression. This leads to a stable equilibrium radius.

The resistance arises from the constituent atoms through the quantum degeneracy pressure of the electrons. The strength of the atomic incompressibility does not depend on the mass. On the other hand, the strength of the gravitational compression increases with the mass as does the corresponding resistance from the electron degeneracy effects. The basic equilibrium is not dependent on either thermal or rotation forces although these will affect the finer details of conditions inside. The essential contribution of gravity will not apply in the near surface region which will be controlled instead by chemical forces alone. There is, then, a surface region called the crust where the equilibrium is different from the interior. The planetary body will always show these two regions and unfortunately the crust separates the observer from the interior. The largest mass of hydrogen

able to contain this equilibrium, where the atoms are strong enough to remain un-ionised by the pressure at the centre, is only slightly greater than the mass of Jupiter. For a silicate composition, the mass would be rather greater but the radius smaller.

Mercury is at the other end of the mass scale. The smallest silicate/ferrous body where gravity can make a contribution will have a radius of perhaps 150 km (a small satellite such as Mimas or a large asteroid) and with a radius 20 times this minimum value, Mercury certainly has an interior controlled by gravity. The effect will be to cause creep in the materials and the heavier minerals will sink towards the centre forcing the less heavy minerals upwards towards the surface. The ferrous component needed to account for the high density will then form a central core which can be expected to account for up to 75% of the entire radius and for in excess of 70% of the total mass. This compares with the Earth where the central half is composed of ferrous materials (divided fairly evenly into a liquid outer core and solid inner core) which contains about 32% of the total mass. The degree of internal compression is less in Mercury than for the Earth because the mass is smaller.

The central pressure is likely to be about one million atmospheres (which compares with the Earth's central pressure of about three million atmospheres). The material there will be plastic but the temperature is quite unknown so the dynamics can only be guessed at the present time. It is unfortunate that the thermal energy plays no part in the overall mechanical equilibrium of a planetary body because there is, as a result, no direct way of estimating the temperature inside. The small gravitational energy will have produced rather lower temperatures than in Venus/Earth at the formation, leading to a less complex mineralogy.

What Would We Like to Know in the Future?

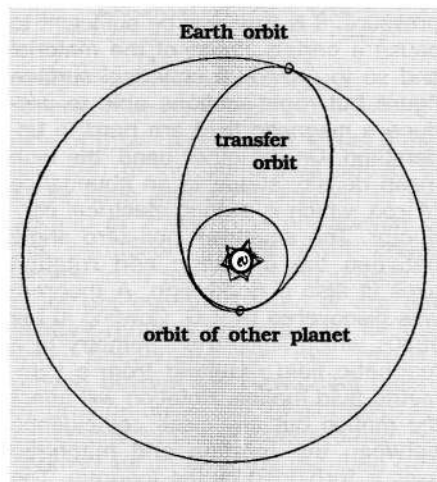
Although it is a small planetary body, further information about Mercury could be of the greatest value in planetary studies. There are many things we would like to know. Many of these could be inferred from the motions and behaviour of an orbiting vehicle. The lack of atmosphere would allow a low orbit to be maintained over a long period of time and this would be especially valuable. Other quantities would require a landing mission and an automated lander must be the ultimate objective.

(a) A Long-life Orbiter

Many basic quantities would be found from such a mission. The most obvious need is a detailed photographic mapping of the entire surface.

It would also allow the presently accepted value for the mass to be unambiguously confirmed. There is a story about the value of the presently accepted mass. It was first given by Newcomb by quoting the inverse mass (which is the ratio of solar mass to mass of the planet) as about 6 million but he seems to have given no details of his deduction. It is the value that has been accepted since. An orbiter would allow Kepler's laws to be applied accurately to give the mass and so the mean density of the planet. Our present ideas about the interior are dominated by the high density and it is essential to confirm this.

Although we know the radius with some accuracy we have little idea of the actual mean figure of the planet and the way it departs from a true



Showing the transfer orbit around the Sun in relation to the orbits of the Earth and the other planet.

spherical shape. There are several aspects to this. First, an accurate figure will tell whether the centre of mass and the geometric centre are at the same point. They are not coincident for the Moon being a few kilometres apart. Second, a knowledge of the figure can imply possible inhomogeneities in the interior, for instance that would have arisen if there had been a convective pattern inside at some earlier stage of the planet's history.

A vehicle in low orbit would allow accurate knowledge of the global gravity field to be accumulated. The observed field is expressed in terms of a variety of multipole components and the relative strengths of the different contributions allow the distribution of matter inside to be inferred. This would allow important constraints to be placed on the possible models for the interior. It would also allow regions of high gravity to be isolated, if they exist, telling something of the crustal conditions. It would be interesting to compare these data with those for the Moon to see whether the histories of these two bodies were indeed comparable.

Great interest must centre on the magnetic conditions near the surface. Is the dipole field dominant and what is the contribution of multipole components? It is necessary to deduce an accurate location for the magnetic poles and to determine whether the magnetic poles are truly anti-polar points.

Any information about the heat budget of the interior would be valuable. Of especial interest is the presence and distribution of radioactive materials. This could be inferred from γ -ray measurements especially. A low orbiter would allow such data to be accumulated.

(b) An Automatic Lander

A manned landing would be both dangerous and unnecessary, at least in the medium term, but an automatic system, perhaps along the lines of the Venera landers on Venus, would have the greatest value. An immediate interest is in the precise material composition of the surface region and of the surface heat flow. This would possibly lead to a dating of the materials and so to the compilation of a firm chronology of the crust. The similarities with the Moon have been stressed earlier and it is important to make a precise comparison between the histories of these two bodies. One outcome would be a comparison of the cratering rates at two locations from the Sun (Mercury and Moon locations) at different periods of the early Solar System. The role of planetesimals at that time is still not known.

A lander vehicle would allow preliminary seismic data to be found giving an indication of the physical conditions inside. Any detailed study using seismology would require an array of seismic stations and this could only be a very long term objective. Two questions are obvious: is the present Mercury seismically active, in comparison with the Moon (and of course the Earth)?; and can a non-rigid region be identified, presumably towards the centre of the planet? Such information has a bearing on a possible source region for the magnetic field. It also has implications for the thermal conditions inside now.

The return of surface material to Earth for detailed laboratory study must be the ultimate objective. It is to be expected that the mineralogy of Mercury is less developed than for Earth because the pressure and temperature were much lower earlier on. How the mineralogy compares with that of the Moon would be of the greatest interest.

Constraints on Such Missions

Mercury orbiters and Mercury landers are far from easy to achieve because of the location of the small Mercury near the massive Sun. To show the difficulties let us consider the usual method of interplanetary

Totality - Here and There

BY PATRICK MOORE

BIS Fellow

travel using a transfer orbit. This is shown in the figure. There are three stages: first a vehicle is put in orbit about the Earth; next, it is placed in an elliptic (transfer) orbit with the Sun at a focus and with major axis equal in length to the sum of the radii of the Earth and of the planet - the vehicle is now in orbit about the Sun; for the third stage the vehicle is transferred from the transfer orbit to the orbit of the other planet. This sounds easy in its plain description but the energy required can be large.

Moving from Earth orbit (which is essentially circular) to the elliptical transfer orbit requires a deceleration of the vehicle for a transfer nearer the Sun. Because the Sun is at the far focus of the elliptic orbit, the vehicle will speed up (according to the requirements of Kepler's second law of planetary motion) as it moves towards the Sun. To orbit at the other planet's distance (again assuming a circular orbit) the vehicle must suffer a further deceleration. The extent of each deceleration depends on the orbit required. The two inner planets Venus and Mercury involve very different decelerations as is seen from the table.

Reduction in speed for a space vehicle to be transferred from Earth to (a) Venus and (b) Mercury.

From Earth to	Venus	Mercury
Reduction in speed to enter:	km/s	km/s
Transfer orbit	-2.5	-7.5
Planet orbit	-2.8	-8.6

The energy requirements for transfer to a Venus orbit are not excessive but those for Mercury are much more severe. The implication for Mercury is that only a vehicle with small mass could be contemplated at the present time. This restricts the possible payload and probably restricts any early mission to one of simple photography but with the bonus of determining the mass and the simple figure of the planet. This would be an extremely worthwhile enterprise.

Conclusion

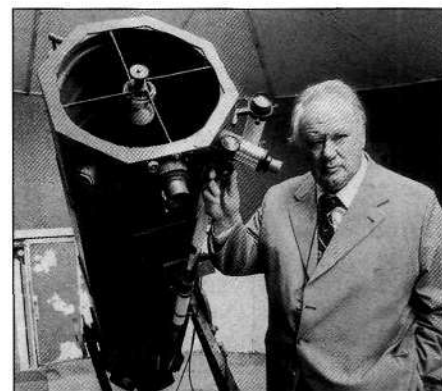
Mercury is almost as enigmatic as Pluto but we have some direct information about it. Although our chances of obtaining more detailed data would not seem very high in the shorter term, it is important to realise the importance such data would carry for relative planetology and for a glimpse of conditions that prevailed during the early history of the Solar System. Many of the uncertainties concerning Mercury have implications for the other planetary bodies as well but it is going to remain difficult to obtain more information about the Winged Messenger.

Last October 24 there was a total eclipse of the Sun. It was not visible from Britain; the track crossed India and went on to the Far East (where I was). The Moon's shadow is only just long enough to touch the Earth, and the track of totality can never be more than 169 miles wide. Moreover, it is sheer chance that the Sun and the Moon appear virtually the same size in the sky; the Sun's diameter is 400 times that of the Moon, but the Sun is 400 times further away. Does this sort of thing happen anywhere else in the Solar System?

If a satellite has an apparent diameter much smaller than that of the Sun seen from the planet, we will have a simple transit, devoid of any of the glorious phenomena of totality. If the satellite appears much larger than the Sun, we will have an occultation of the Sun, but again without the full beauty of totality as seen from Earth. So let us cast around.

Begin with Mars. Here we have two small satellites, Phobos and Deimos, which are probably ex-asteroids; both are less than 30 km across, and both move virtually in the plane of the Martian equator, so that alignments are common enough. However, all we can expect are transits. From Mars, the apparent diameter of the Sun is, on average, 21 minutes of arc. Phobos would have a maximum diameter of 12.3 minutes, Deimos a mere 8 minutes. Phobos would transit the Sun 1300 times in every Martian year, taking 19 seconds to cross the disk; Deimos would produce about 130 transits, each taking 1 minute 48 seconds. So to a Martian observer, totality is unknown.

Next let us go to Jupiter. (I am not suggesting landing there, which would be a little difficult, but there is no harm in letting one's imagination run riot.) The Sun's diameter is now just over 6 minutes of arc. The fifth satellite, Amalthea, will more than cover this, but the tiny inner satellites would not. All the four Galileans would appear far



larger than the Sun - their apparent diameters would range from over 35 minutes of arc (Io) to just below 10 minutes of arc (Callisto).

Saturn, then? Now the Sun has shrunk to a disk less than 4 minutes of arc across, and all the major inner satellites would loom much larger than this. It seems that the best spectacle would be produced by the outermost of the main satellites, Iapetus, which is much smaller than our Moon and moves round Saturn at a distance of over 3,500,000 km in a period of 79 days. From the planet, Iapetus would have an apparent diameter of almost 2 minutes of arc, which is inadequate to produce totality but would give a reasonable impression of an annular eclipse. However, Iapetus - alone of the principal satellites - has an appreciable orbital inclination to Saturn's equator, and this would reduce the number of eclipses.

When we go out to Uranus and Neptune, the Sun seems so small that eclipses would be rather meaningless, though each planet has satellites big enough to cover the Sun. Pluto, of course, is unique; its attendant, Charon, has an orbital period which is the same as Pluto's rotation period (6 days 9 hours), and to a Plutonian observer Charon would hang motionless in the sky. Its size would be about one-fifth that of the Moon seen from Earth, and its apparent magnitude would be -9.

All in all, it seems that we on Earth are particularly favoured. Only from here is it possible to see the full beauty of a total solar eclipse.

This photograph of the solar eclipse of 7 March 1970 was taken at Miahuatlan, Mexico. Totality lasted for three and a half minutes. The Manned Spacecraft Center, Houston, Texas had a team of scientists, astronomers and technicians at Miahuatlan to observe this outstanding phenomenon.



Radarsat

October 20 1995 is when Radarsat is to be launched. It is not the first satellite to use Synthetic Aperture Radar (SAR), but it is the world's first one to do so commercially.

Introduction

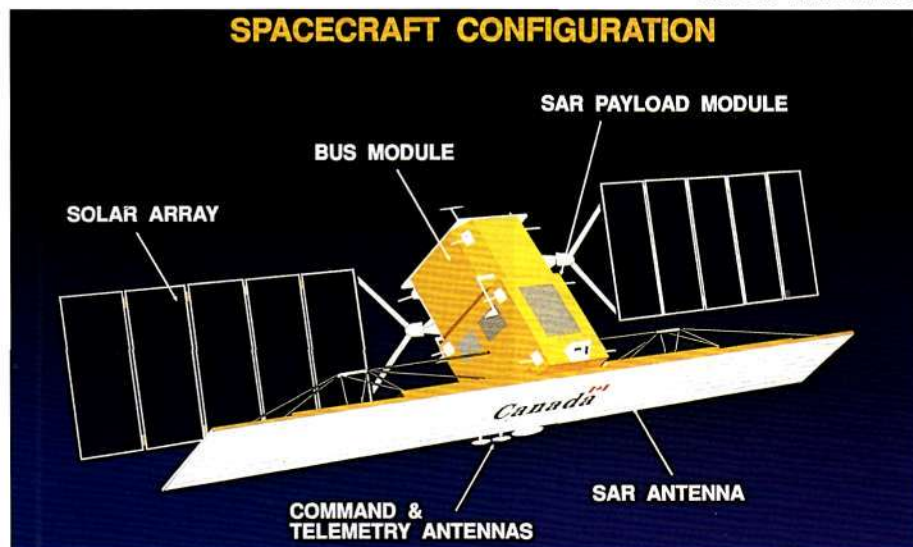
The difference between Radarsat and other SAR satellites (Seasat, Almaz, ERS-1) is that the others were launched "primarily for research purposes" and "were not operated on a commercial basis", according to Dr John Hornsby, Director of Operations for Radarsat International Inc. (RSI). Being a commercial satellite means that Radarsat will carry no experiments, its orbit will remain consistent during its lifetime, and the highest priority for the satellite will be the collection of images for sale to its customers.

Canada has become a world leader in the collection and interpretation of remote sensing data due to its huge land mass and small population. Building and operating a satellite has been the next step in meeting the country's unique Earth observation needs. Another factor in the decision to build Radarsat was Canadian economic development. Landsat and SPOT have shown that for every \$1 in images sold, \$8 in related services are generated. Such services range from the building of Radarsat ground stations to an individual selling his ability to interpret images for a particular application.

Radarsat is expected to sell \$180-200 million (Canadian) worth of images during its 5 year lifetime. Applying the 1:8 economic multiplier effect to these sales figures, it becomes apparent that Radarsat will have a major effect on the Canadian remote sensing industry.

An in-orbit illustration of the fully deployed Radarsat. The actual assembly of the SAR payload module with the bus module is seen in the photo on the opposite page.

CANADIAN SPACE AGENCY

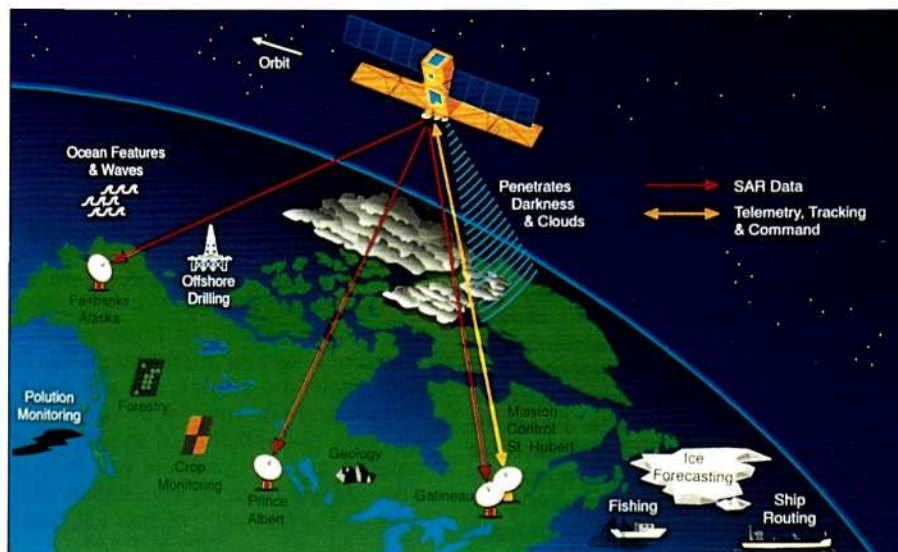


BY BARRY SHANKO

British Columbia, Canada

Below: An overview illustration of the Radarsat mission and the many types of targets that may be studied from its images.

CANADIAN SPACE AGENCY



How Radarsat Came About

Canada has two concerns with its Arctic coastline: enforcing its claim to the area and patrolling the shipping lanes for icebergs and ice sheets.

If Canada cannot monitor the Arctic, any claim to jurisdiction is meaningless. This was emphasised several times during the 1970s and 1980s when foreign ships used the Northwest passage without Canada's permission. Having a way to track ships in the area strengthens Canada's case.

The safety of ships using the Arctic is a Canadian responsibility. Ice threatens shipping all year around. The Canadian Coast Guard, oil and gas exploration ships, icebreakers and commercial ships all use these waters. For

these ships, timely and accurate ice information is a life and death matter.

Previous monitoring methods have two drawbacks. The first is that they depend on machinery being located in the Arctic. The second is that they need human operators in order to work. The harsh Arctic climate is hostile to both men and machine.

During the 1970s it became apparent that a satellite-based system offered the best solution to the Arctic monitoring problem. The then-new technique of SAR emerged to enable observations to be made during the hours of darkness or in the presence of cloud cover.

Canada started the Radarsat project in 1976. As the design study progressed, the two highest priorities for Radarsat became, "ice monitoring in the North and high resolution mapping for agriculture" stated Dr John Hornsby. The definition stage was finished in the early 1980s. The plan called for a spacecraft that could be maintained on-orbit with a lifetime of 15 years. It was to be launched by the Space Shuttle from the Vandenberg launch pad. The estimated cost was \$750 million (Canadian). The plan was submitted to the Canadian government for approval.

Cabinet rejected this plan, stating that it was too expensive. Designers cut the costs and re-submitted a revised plan which was approved by the government on 25 June 1987 and detailed design work started.

The new spacecraft would have a lifetime of 5 years. It would not be launched on the Space Shuttle as the Challenger accident had led to the closing of the Vandenberg launch

complex. Radarsat would ride into orbit on a Delta rocket at a reduced cost of \$500 million.

The Canadian federal government's contribution is \$350 million and the American government is providing \$75 million in the form of a Delta rocket. In return, the Americans will get free Radarsat images up to a value that equals the cost of the rocket. \$54 million has been provided by Canadian provincial governments and private users of Radarsat in the form of a pre-payment for images. This is in contrast to both SPOT and Landsat where the government covered the entire cost of building and launching the satellite with private money coming into the system after the craft was operating.

Private sector support for Radarsat has been greater than expected and Radarsats 2 and 3 are expected to get even greater support from the private sector than Radarsat 1. This will allow the Canadian government to reduce its share of the upfront costs.

Radarsat International Inc (RSI) is a private company created to be the world-wide sales and marketing arm of the project. It was founded in 1989 by three Canadian high technology companies: SPAR Aerospace Ltd; COM DEV Ltd; and MacDonald-Dettwiler and Associates Ltd. RSI is spending \$20 million (Canadian) of its own money on a marketing and educational campaign to introduce Radarsat to the international remote sensing community. RSI President, Robert E. Tack explained, "We need to educate the user community in order to drive demand". RSI profits will be channelled into Radarsat-related R&D, which should create even more demand for Radarsat. This process is the one that will "make Canada number one in this field", stated Tack.

Radarsat's SAR

The prime contractor for the satellite is SPAR Aerospace Limited, of Toronto, Ontario. The company is fa-



SPAR personnel lower the SAR payload on to the bus below during the Radarsat bus/payload mating operation.

DAVID FLORIDA LAB/CRS/COMMUNICATIONS RESEARCH CENTRE

mous for building the Space Shuttle's "Canadarm" in addition to several communication satellites. The spacecraft's construction was finished in late 1994. It was then transported to the David Florida Laboratory to undergo pre-launch testing. The electronics were provided by COM DEV Limited of Cambridge, Ontario.

Radarsat's launch mass is 2750 kg. The twin solar panels produce 3.5 kW of power. The SAR antenna's size is 15.0 m x 1.5 m. The SAR has a peak power output of 5 kW, with an average output of 300 W, and operates in

C-Band (5.3 GHz). The polarisation is HH which means that the radar transmits a horizontally polarised microwave beam to the ground and it receives a horizontally polarised reflection. This class of polarisation renders strong water/ground and water/ice contrast.

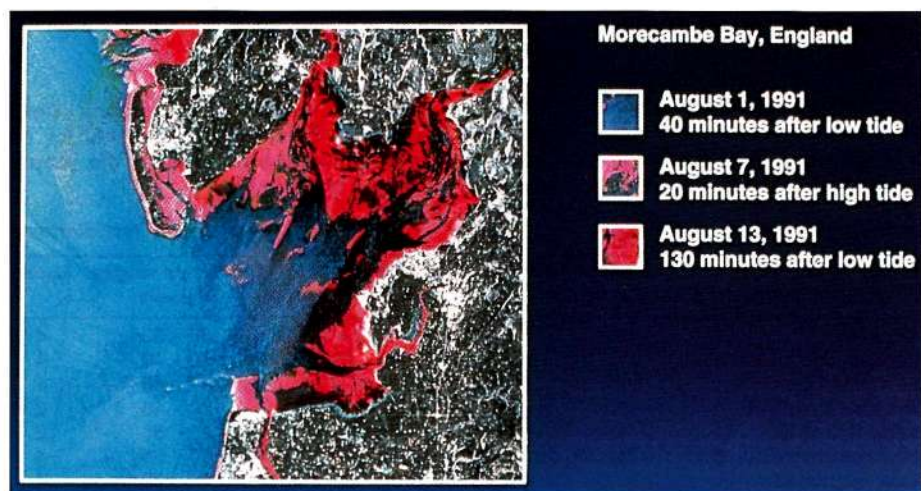
The SAR can image up to 28 minutes per orbit. Using a 500 km wide swath, this translates into imaging an area of 1.1 million square kilometres. The data can be sent directly from the spacecraft to a ground station during imaging or, if one is not available, it can be stored on one of two tape recorders.

Radarsat can see the whole Arctic above 79°N every 24 hours, all of Canada every 3 days and any point on the equator in 4 days. The orbit is sun-synchronous and this allows the solar panels to receive nearly continuous solar illumination. The spacecraft is not therefore heavily dependent on battery power and the amount of time the spacecraft is available for operations is correspondingly increased. The spacecraft will orbit at a height of 798 km at 98.6° with a period of 100.7 minutes.

The SAR itself is the most advanced ever flown on a civilian spacecraft. For comparison, the ERS-1 satellite, the most advanced radar satellite yet flown has a single incidence angle (the angle between the incoming radar beam and the local vertical at the spot

This ERS-1 image shows that accurate radar mapping of farmland and coastlines is feasible. The area is of Morecambe Bay, England at different observing times and the difference between the tide flat and the agricultural land around is easily seen.

RADARSAT INTERNATIONAL



EARTH OBSERVATION

where the beam hits the ground) of 23°; one swath width (the width of the ground illuminated by the radar beam) of 100 km; and one resolution of 30 m.

The antenna on Radarsat's SAR can be moved or "steered", using a phased-array technique, in order to change the incidence angle. The angle varies from 20° at the point closest to the spacecraft's ground track, to 50° at the point furthest away, and all the angles between these limits.

These incidence angles produce a swath on the ground beginning 250 km away from the ground track and ending 750 km distant. This gives a swath width of up to 500 km of which any point can be imaged.

The SAR can illuminate an area 10° on either side of the normal swath. These zones, called the "Extended" zones, are considered experimental by the project. But, it is believed that images taken there will be as good as any obtained in the regular swath.

Customers can choose resolutions ranging from 10 m at best to 100 m at worst. The available radar modes, resolutions and their swath widths are summarised in the Table below.

The radar has a unique mode called "ScanSAR". In every other mode, the width of the radar beam doing the imaging is smaller than the swath width and, if the customer needs to image across the entire swath, the beam must be moved or "stepped" along the entire width, taking an image at each step. Wide ScanSAR mode images across the whole 500 km swath, instantly, with only a single radar beam. It produces a resolution of 100 m. Narrow ScanSAR has a resolution of 50 m, but it can only image across a swath width of 300 km. Both modes are intended for users who need repeat coverage of large areas at low resolutions. This mode will be used to monitor the ice in the arctic shipping lanes.

Antenna steering allows for more frequent coverage of the Earth than does a fixed antenna. When the antenna is fixed, the location of the swath in relation to the spacecraft's ground track is fixed. If the orbit of the spacecraft is not one that carries the swath through the target, no imaging is possible. The customer must wait until the orbit carries the swath through the target. With Radarsat the antenna can be pointed at the target, within the limitations of the system, and this creates more frequent opportunities to see a target. This has advantages in seeing rapidly changing events like flooding or other natural disasters where seeing the target within a short period of time after the event may be a life or death matter.

Radarsat Uses

Sea Ice Tracking

The SAR's strong water/ice contrast will make it ideal to find and track

Arctic ice and to determine the following information in all weather conditions: ice age; ice concentration; ice edge detection; ice roughness; and ice movement. Radarsat could help to detect early signs of global warming by looking for signs of higher than normal levels of melting ice.

SAR provides information on the age of ice because, as ice gets older, it becomes brighter in SAR images due to the internal changes and sandblasting of its surface by wind-carried particles. Older ice is stronger, and hence more of a threat to ships, than new ice. By studying Radarsat images, a ship's captain can steer a safe course using up-to-date ice information.

Disaster Monitoring

Radarsat's combination of strong ground/water contrast and frequent fly-overs of any point on Earth makes it ideal for disaster assessment and monitoring with collection of images before, during and after the event. Preventive actions can be taken and insurance companies and government relief agencies can determine compensation amounts.

Oil and Gas Exploration

Some of the more interesting places on Earth to explore for oil and gas fields are located in the tropics in places like Vietnam and Papua New Guinea, but, they are also places with heavy and widespread cloud cover and dense jungle vegetation. SAR is able to overcome these limitations. Also, by taking images on successive passes over the target and changing the incidence angle between passes, stereo images are created.

Mapping

Radarsat will aid in mapping the Earth, particularly in coastal and tropical areas. Frequent passes allow tidal flats to be easily separated from land that is not subjected to tidal flooding and this will aid urban planners in determining where roads, railways and other structures should be placed. The 10 m resolution mode allows tax and assessment authorities to find out to what use land is being put and assess the proper rate of taxation.

The unique problems that tropical countries have in being accurately mapped was explained by Dr John Hornsby. "Consider the case of a nation like the Philippines. It is a scattered collection of many islands

spread over a huge area. This area is difficult to map by conventional means. It is a perfect job for Radarsat."

Radarsat International Inc (RSI)

RSI, as mentioned earlier, exists to be the sales and marketing arm of the Radarsat project. Between 1985 and 1994, the fees collected from selling remote sensing data were \$615 million (Canadian) world-wide. The years from 1996 to 2000 should see sales grow to \$1.325 billion. RSI wants to attain 20% of this market.

Once Radarsat is launched, RSI forecasts that 90% of its sales will be to countries other than Canada. Of those foreign sales, 80% are expected to be to the Asia-Pacific region.

Once a customer places an order for Radarsat images, it is evaluated in terms of spacecraft scheduling and SAR mode(s) and then sent to the Mission Management Office, the Radarsat control centre, located at the Canadian Space Agency headquarters in St Hubert, Quebec.

Normally, it takes a few weeks from the time the customer places the order to the time it is ready to be delivered. In an emergency, this time can be shortened to days. The Canadian Ice Centre, the agency that has the task of monitoring the northern shipping lanes, has a special arrangement with RSI. They will get their images within four hours of Radarsat collecting them.

Ground stations now exist at: Prince Albert, Saskatchewan; Gatineau, Quebec; and Fairbanks, Alaska, but they will eventually cover the world. The stations are manufactured by MacDonald-Dettwiler and Associates Limited located in Richmond, British Columbia.

After launch, the spacecraft will be put through an extensive check-out and when this has been completed Radarsat is open for business.

Radarsat 2 is now being designed and is virtually a clone of the first spacecraft, with only minor changes to reflect operational experience. Launch is planned for 1999. Radarsat 3 is in the planning stage and may be a joint effort between the Canadian Space Agency, RSI, and the SPOT Image Corporation.

Acknowledgement

The author wishes to thank Cory Aspdon of Radarsat International for all the help that she provided in the preparation of this article.

Radarsat Imaging Modes.

RADARSAT INTERNATIONAL

Beam Mode	Positions	Overlap	Swath width (km)	Resolution range x azimuth (m)	Incidence angles degrees(°)	Looks
Standard	7	>10%	100	25 x 28	20 - 50	4
Wide Swath	3	3%	150 - 165	48 - 25 x 28	20 - 40	4
Fine resolution	5	10%	45	11 x 9	37 - 48	1
Narrow ScanSAR			300	50 x 50	20 - 40	2
Wide ScanSAR			500	100 x 100	20 - 50	2
High incidence	6	3%	75	22 - 19 x 28	50 - 60	4
Low incidence			170	63 - 28 x 28	10 - 20	4

CANYON, RHYOLITE and AQUACADE:

US Signals Intelligence Satellites in the 1970s

BY
CHRISTOPHER ANSON PIKE
Virginia, USA

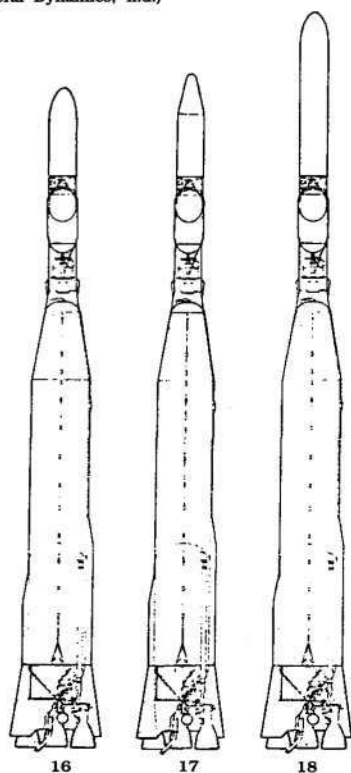
Most reports on US signals intelligence satellites state that the RHYOLITE series was the first and most common sigint satellite system fielded by the United States in the 1970s. New evidence now disputes this. An Air Force programme known as CANYON was the first high-altitude signals intelligence satellite and more common than RHYOLITE. While only four RHYOLITE/AQUACADE satellites were fielded, seven CANYON satellites were launched atop Atlas Agena D rockets, six successfully reaching orbit. Recent research has uncovered new information on this satellite programme.

Little was known about CANYON before this new data was obtained and analyzed. What was known was that CANYON was an Air Force communications intelligence satellite that had operated sometime during the 1970s, apparently replacing the low Earth orbit "heavy ferrets." The satellite had reportedly been the subject of some bureaucratic rivalry between the Air Force and the Central Intelligence Agency, which was then fielding its own RHYOLITE series of satellites. CANYON apparently had an antenna diameter of only about three meters, vs. approximately 19 meters for RHYOLITE, although the source of this information is of questionable accuracy [1].

The first satellite of this series was launched on 6 August 1968, atop the

Comparisons of different Atlas Agena D launch vehicle configurations. Vehicle 16 was apparently the Program 827 (CANYON) configuration. Vehicle 18 was apparently the Program 720/472 (RHYOLITE/AQUACADE) configuration. Vehicle 17 was apparently never used.

(Source: Atlas Launch Vehicle evolution charts, General Dynamics, n.d.)



first "stretched" Atlas Agena D. This version of the Atlas had longer fuel tanks and thus increased payload performance [2]. The Eastern Test Range *Index of Missile Launchings* for Fiscal Year 1969 stated that an Atlas Agena launch vehicle had "Boosted a classified payload of experimental nature into near circular earth orbit. News-men assigned various unofficial designations of their own to the payload, but there was not official pronouncement of its nature from the Air Force. It was the first closed launch from the Cape since 1963" [3]. The *Index* estimated the payload weight at approximately 500 pounds [4]. It was placed into a quasi-synchronous orbit. The *Index* stated that a second launch on 12 April 1969, "Boosted classified payload of experimental nature into near circular earth orbit. This was the second closed launch of the current series started in August 1968" [5]. The "Earth Satellite Programs" table for the FY 1969 *Index* listed the two satellites as "Unnamed Classified" [6].

The Royal Aircraft Establishment *Table of Earth Satellites* listed the first launch, with the international designation of 1968-063A, as "BMEWS 1" for "Ballistic Missile Early Warning System". It provided orbital parameters of 9.9° inclination and 31,680 by 39,860 km orbit with a period of 1,436 minutes [7]. It also stated that the Agena D rocket was "probably in an orbit similar to 1970-46B" which it identified as the Agena for "BMEWS 3". This is incorrect. The second launch on 12 April 1969, with the international designation of 1969-036A, was labelled "BMEWS 2" and was in a 9.9° inclined, 32,670 by 39,270 km orbit [8].

On 19 June 1970, another satellite was launched from the Eastern Test Range and the ETR *Index* stated that the rocket "Boosted classified experimental satellite payload into earth orbit under Program 827. This was the third Program 827 payload launched from ETR" [9]. The RAE *Table* listed this satellite, with the international designation 1970-046A, as "BMEWS 3" and provided initial orbital data for a transfer orbit: 28.21° and 178 by 33,685 km [10]. This data, however, was not consistent with the two previ-



Rare photo of a long shroud Atlas Agena rocket used to launch the RHYOLITE/AQUACADE signals intelligence satellites. (Photo courtesy of LEE CALDWELL and KEITH SCALA)

ous launches since the apogee was indicative of a satellite headed for a geosynchronous orbit. The initial apogee is usually the same altitude or slightly below the desired orbit and the initial perigee is subsequently raised until the desired orbit is achieved. Occasionally, the apogee is raised during the transfer orbit phase, but the fact that the initial apogee of the satellite was approximately 6,000 km below the two earlier launches made this seem doubtful and it was more likely that the apogee would be raised to a geosynchronous orbit of around 35,200 km. Two explanations were possible: either the first two satellites were identical and the third was different and the term "Program 827" was used to refer to all East Coast classified launches, or the ETR *Index* was in error and the third satellite was not the third Program 827 launch.

Fortunately, the picture got a little clearer with the next classified East Coast Atlas Agena D launch on 31 August 1970. This satellite, 1970-069A, and identified as "BMEWS 4" by the RAE *Table*, had orbital characteristics of 10.3° at 31,947 by 39,855 km [11]. Pages 3 and 4 on the Atlas Agena D launches of the relevant ETR *Index* are classified and were not released. However, the "Earth Satellite Programs" table was not classified. It lists two launches of Program 827 satellites in FY 1969, a single launch of a "Program 720" satellite in FY 1970, and a third Program 827 launch in FY 1971 [12]. Furthermore, it lists the second and third Defense Support Program launches in FY 1971, which rode into orbit atop Titan III boosters (the first satellite, launched on 6 November

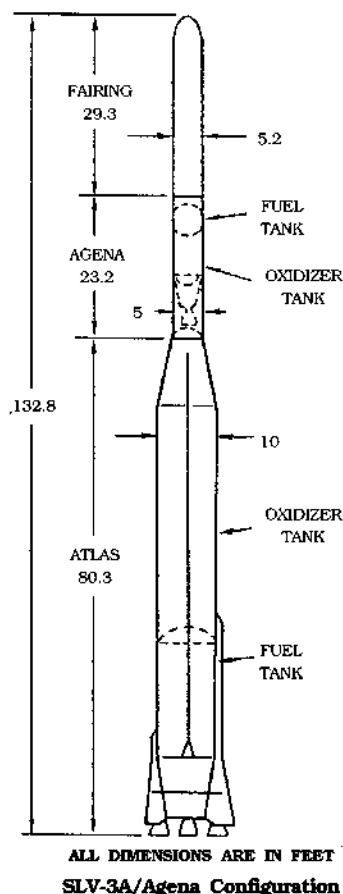


Diagram of Atlas Agena rocket with extended payload shroud which was used to launch the RHYOLITE/AQUACADE series of signals intelligence satellites.

(Source: Space and Missile Systems Organization: A Chronology 1954 - 1979 Office of History, Headquarters, Space Division.)

1970, was placed into the wrong orbit, but was still able to be tested). This is an important fact, for it is highly unlikely that the United States was operating two ballistic missile early warning systems simultaneously.

In fact, new evidence, now indicates that there were no early warning system satellites launched by the United States between the launch of the last Program 461 satellite on 5 October 1966, (part of the Midas programme) and the first DSP launch in late 1970. A March 1992 DSP programme briefing presented by the DSP Program Director indicated that the RDT&E funding for the first DSP Phase 1 satellite was begun in FY 1966 [13]. Furthermore, Space Systems Division histories of the programme indicate that no other early warning test launches took place between the end of Program 461 and the launch of DSP F-1. Although there were follow-on "Program" designations of Program 266, 946 and Program 647, no satellites were launched with these designations, which all referred to the on-going effort to develop a geosynchronous early warning satellite which eventually became known as the Defense Support Program.

The use of the quasi-synchronous orbit, ranging from 9 to 10.3 degrees and with a perigee of 30,200 to 32,670 km and an apogee of 39,270

to 40,800 km is rather unusual and unexplained. Rather than remaining stationary over a single point on the Earth, the satellite appears to slowly wander over the horizon. Possible reasons for using these orbits include increasing the monitoring area and taking multi-position bearings on emitters [14]. This in turn dictated that more than one satellite be used to obtain continuous coverage of the Soviet Union as the satellites drifted over the horizon.

On 4 December 1971, an Atlas Agena D carrying a Program 827 satellite suffered a launch failure and the satellite did not reach orbit [15]. The fourth successful launch, and fifth in the Program 827 series, took place on 20 December 1972. This Program 827 satellite, labelled "BMEWS 5" in the RAE Table and with the international designation 1972-101A, entered an orbit with an inclination of 9.7° at 31,012 by 40,728 km [16]. On 6 March 1973, another launch took place. This was a Program 720 satellite with the international designation of 1973-013A.

The sixth Program 827 launch took place on 18 June 1975. The satellite, 1975-055A, entered a 9°, 30,200 by 40,800 km orbit [17]. The RAE Table identified this as a Titan IIIC rocket, however, the ETR Index for the relevant period identifies the launch as an Atlas Agena D and states "Atlas Agena boosted advanced spacecraft into earth orbit carrying various scientific experiments" [18]. The payload information on the launch was deleted from the report [19]. Other reports on the Atlas rocket now indicate that this was indeed an Atlas and not a Titan launch.

The final Program 827 launch apparently took place in 1977. By this

time, the ETR Index of Missile Launchings had switched from a Fiscal Year reporting period (July to June of the following year) to a calendar year reporting period. Although the individual launch listing for the two classified Atlas Agena D missions launched that year was not declassified, the "Earth Satellite Programs" table of the Index lists a single Program 827 launch and a single "Program 472" launch, but does not indicate which launch took place in which half of the year. By this time, Program 720, also known as RHYOLITE (covered elsewhere), had been compromised to the Soviet Union by the convicted traitor Christopher Boyce. The satellite name would have been changed and thus it is likely that Program 472 was the new designation for Program 720. But this does not establish which of the two launches was which. Normally, the Program could be determined by looking at the orbital data. Program 720 satellites entered into near geosynchronous orbits with inclinations near zero. Program 827 satellites had slightly elliptical orbits with inclinations between 9 and 10.3 degrees. But the orbital data for both the transfer and final orbits of the December 11, 1977 launch of 1977-114A are *exactly* the same as the orbital data for the earlier 23 May 1977 launch of 1977-038A. The final orbits for both these satellites are also exactly the same for the earlier 6 March 1973 launch of 1973-013A, which was a RHYOLITE. The dates of orbital determination for transfer orbit and final orbit for the May launch are 24 May and 1 June respectively and 12 December and 1 January 1978, for the December launch.

The most likely conclusion would be

Table 1. Summary of Atlas Agena D Sigint Satellite Series.

Date	Program	Intl. Desig.	Name	Inclin.	Perigee	Apogee	RAE Name
06.08.68	Program 827	1968-063A	CANYON-1	9.9	31,680	39,860	BMEWS 1
12.04.69	Program 827	1969-036A	CANYON-2	9.9	32,670	39,270	BMEWS 2
19.06.70	Program 720	1970-046A	RHYOLITE-1	28.21°	178	33,685	BMEWS 3
31.08.70	Program 827	1970-069A	CANYON-3	10.3	31,947	39,855	BMEWS 4
04.12.71	Program 827	N/A (failure)	CANYON-4	N/A	N/A	N/A	N/A
20.12.72	Program 827	1972-101A	CANYON-5	9.7	31,012	40,728	BMEWS 5
06.03.73	Program 720	1973-013A	RHYOLITE-2	0.2°	35,679	35,855	BMEWS 6
18.06.75	Program 827	1975-055A	CANYON-6	9.0	30,200	40,800	N/A
23.05.77	Program 827	1977-038A	CANYON-7	0.2°	35,679	35,855	N/A
11.12.77	Program 472	1977-114A	AQUACADE-1	0.2°	35,679	35,855	N/A
07.04.78	Program 472	1978-038A	AQUACADE-2	28.4°	150	35,033	N/A

* Initial orbit.

† Identical orbital information given.

N/A = "Not Applicable" or "Not Available"

Table 2. Those Entries of Table 1 for which Values are in Dispute.

Date	Program	Intl. Desig.	Name	Inclin.	Perigee	Apogee	Det. Date
06.03.73	Program 720	1973-013A	RHYOLITE-2	28.27	228	33,584	19.03.73*
				0.2	35,679	35,855	01.04.73
23.05.77	Program 827	1977-038A	CANYON-7	28.2	191	41,002	24.05.77
				0.2	35,679	35,855	01.06.77
11.12.77	Program 472	1977-114A	AQUACADE-1	28.2	191	41,002	12.12.77
				0.2	35,679	35,855	01.01.78

* Date of Determination

** Data for Agena D rocket.

that the May 1977 launch was a Program 827 satellite and the December 1977 launch was a Program 472 launch and that final orbit data for both satellites was taken from the earlier 1973 launch. It is also reasonable to conclude that the December launch used data from the transfer orbit from the earlier May launch. The apogee for transfer orbits of both satellites is 41,002 km, which is higher than the alleged final apogee of 35,855 km, and is consistent with the Program 827 orbit. Thus, it is possible that the May satellite was a Program 827 launch as typified by the high apogee of the transfer orbit and that, lacking data for the final orbit of the May launch, and both the transfer and final orbits of the December launch, the compilers of the list simply plugged in the data from the earlier launches. The *Table* has done this on at least one other occasion, reprinting orbital data for the 6 February 1977 launch of DSP F-7, which is identical to that for the 25 June 1976 launch of DSP F-6.

This conclusion is backed-up by photographic evidence. There are only a few surviving photographs of either the Program 827 or 720/472 launches. The only remaining classified Atlas Agena D launch photograph in Patrick Air Force Base history files depicts a launch in May 1977. The vehicle has a short payload shroud, consistent with the smaller Program 827 satellites and indicating that the earlier assumption about the sequence of launches was correct. Although several official Air Force history documents contain drawings of an Atlas Agena D with a very long payload shroud, no photos were believed to exist of this vehicle until 1991, when Mr. Lee Caldwell and Mr. Keith Scala (a correspondent for both *Quest* and *Countdown* magazines) discovered several amateur photographs of one of these vehicles.

The May 1977 Program 827 launch was the seventh and last satellite in the series. In addition to the December 1977 Program 472 launch, only one more Atlas Agena D launch of a classified sigint satellite took place in April 1978. The orbital parameters and ETR *Index* indicate that this was a Program 472 satellite—the fourth and last of the 720/472 series. As a result, the series of Atlas Agena D sigint satellites can be summarized in Table 1. The disputed data are presented in Table 2.

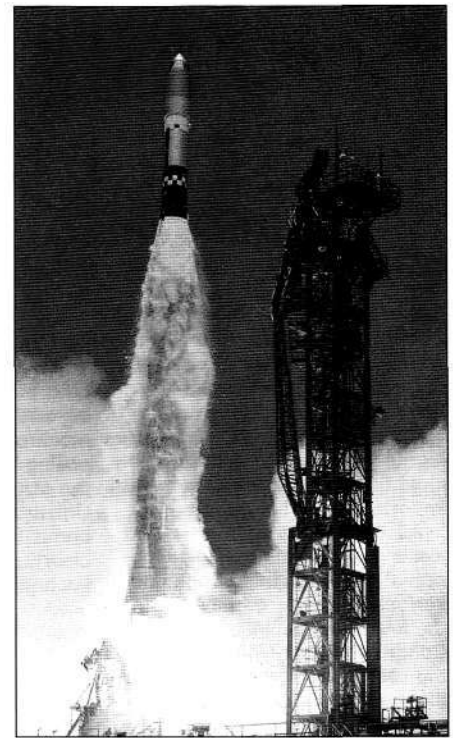
Beginning in 1978, the Program 827 satellites were apparently replaced by

a new series of larger satellites under Program 366 and initially referred to as CHALET [20,21]. These flew atop Titan IIIC launch vehicles and initially had orbits nearly identical to the Program 827 satellites. The name of the first and all subsequent satellites was changed to VORTEX in 1979 [22]. A total of six of these satellites were launched, with the fifth satellite in the series placed in an improper orbit. They are listed in Table 3. It is interesting to note that the number of these satellites is in the same range (6 vs. 7) as the series it replaced. The 720/472 series of satellites was reportedly replaced with a new series code-named MAGNUM and launched on the shuttle. Once again, the number of satellites in the new series is comparable with the series it replaced (3 vs. 4). This may indicate that the slightly elliptical, slightly inclined orbit continued for all the VORTEX launches (the latter launches were classified), since more satellites are required for continuous coverage for these satellites than if they were simply placed in geosynchronous orbit like the RHYOLITE/AQUACADE and MAGNUM satellites. The fewer number of satellites is also probably dictated by the targets they cover. Since RHYOLITE/AQUACADE and MAGNUM were apparently primarily focused at Soviet ballistic missile test facilities, a large number of satellites was not necessary.

In August 1994 and May 1995, two new, very large geosynchronous satellites were launched atop Titan IV Centaur rockets. These are probably the successors to both VORTEX and MAGNUM.

References

1. Major A. Andronov, "Amerikanskiye sputniki radioelektronnoy razvedki na geosinkhronnykh orbitakh," *Zarubezhnoye voyennoye obozreniye*, No. 12, 1993, pp. 37-43.
2. *Space and Missile Systems Organization: A Chronology, 1954 - 1979*, Office of History, Headquarters Division, p. 194.
3. *Fiscal Year 1969, Eastern Test Range Index of Missile Launchings, July 1968-June 1969*, compiled by Marvin R. Whipple, Chief, Historical Division, Air Force Eastern Test Range, Patrick Air Force Base, Florida, p. 3.
4. *Ibid.*, p. 32.
5. *Ibid.*
6. *Ibid.*, p. 25.
7. *RAE Table of Earth Satellites*, Her Majesty's Stationery Office, London, 1981, p. 171.
8. *Ibid.*, p. 194.



Last launch of a CANYON satellite on 23 May 1977. Note the short payload shroud.

9. *Fiscal Year 1970, Eastern Test Range Index of Missile Launchings, July 1969-June 1970*, compiled by Marvin R. Whipple, Chief, Historical Division, Air Force Eastern Test Range, Patrick Air Force Base, Florida, p. 3.
10. *RAE Table of Earth Satellites*, p. 228.
11. *RAE Table of Earth Satellites*, p. 234.
12. *Fiscal Year 1971, Eastern Test Range Index of Missile Launchings, July 1970-June 1971*, compiled by Marvin R. Whipple, Chief, Historical Division, Air Force Eastern Test Range, Patrick Air Force Base, Florida, p. 25.
13. Col. J. Kidd and 1Lt. H. Caldwell, "Defense Support Program: Support to a Changing World," paper presented at American Institute for Aeronautics and Astronautics Space Programs and Technologies Conference, March 24-27, 1992, AIAA 92-1518, p. 12.
14. "Amerikanskiye sputniki radioelektronnoy razvedki na geosinkhronnykh orbitakh," *Ibid.*
15. *Fiscal Year 1972, Eastern Test Range Index of Missile Launchings, July 1971-June 1972*, compiled by Marvin R. Whipple, Chief, Historical Division, Air Force Eastern Test Range, Patrick Air Force Base, Florida, p. 21.
16. *RAE Table of Earth Satellites*, p. 318.
17. *Ibid.*, p. 408.
18. *Fiscal Year 1975, Eastern Test Range Index of Missile Launchings, July 1974-June 1975*, compiled by Marvin R. Whipple, Chief, Historical Division, Air Force Eastern Test Range, Patrick Air Force Base, Florida, p. 3.
19. Payload information was contained on page 40 of the report, *ibid.*, p. 3.
20. *Calendar Year 1978, Eastern Test Range Index of Missile Launchings, January-December 1978* compiled by Marvin R. Whipple, Chief, Historical Division, Air Force Eastern Test Range, Patrick Air Force Base, Florida, p. 38.
21. Richard Burt, "U.S. Plans New Way to Check Soviet Missile Tests," *The New York Times*, June 29, 1979, p. A3.
22. William Burrows, *Deep Black*, Random House, New York, 1986, p. 192.

Table 3. The Series of Six Larger Satellites of Program 366.

Date	Name	Intl. Desig.	Inclination	Perigee	Apogee
10.06.78	CHALET-1	1978-058A	12°	29,929	42,039
01.10.79	VORTEX-1	1979-086A	7.5°	30,443	41,497
31.10.81	VORTEX-2	1981-107A	N/A	N/A	N/A
30.01.84	VORTEX-3	1984-009A	N/A	N/A	N/A
02.09.88	VORTEX-4	1988-077A (USA-31)	29.3°	151	14,103
10.05.89	VORTEX-5	1989-035A (USA-37)	27.5°	455	40,073

The Gamma Ray Sky with Compton GRO and SIGMA

M. Signore, P. Salati and G. Vedrenne, Kluwer Academic Publishers, PO Box 989, 3300 AZ Dordrecht, The Netherlands, 1995, 417pp, £124, ISBN 0-7923-3440-X.

The Compton Gamma Ray Observatory, now in operation for over three years, was the second in the NASA Series of Great Observatories and one which provided a dramatic increase in capability over previous Gamma Ray missions.

Both spacecraft and its instruments continue to function almost flawlessly, leading to many important new discoveries.

All this points to a new and exciting area of astronomical observation and this book describes both the capabilities of the four scientific instruments on Compton and highlights some of the results from the first part of the mission, including the discovery that gamma ray bursts are spatially inhomogeneous in distribution and show evident time-dilation effects in their durations.

More than 30 contributions enlarge on topics such as extragalactic gamma-ray sources, gamma ray backgrounds, galactic gamma ray sources, bursts and spectroscopy.

Particularly interesting contributions are those which relate to observations of the centre of the Milky Way system, obscured from view in the optical wavelengths by interstellar dust. Compton has allowed clarification and further identification of the complex regions around the galactic centre, leading to the detection of 14 sources (to October 1993) nearly all of which are variable, most strongly so, and which attest both to their small sizes and violent natures. The current theory is that they are X-ray binaries which harbour either a black hole or a neutron star.

Cosmology: the Origin and Evolution of Cosmic Structure

P. Coles & F. Lucchin, John Wiley & Sons Ltd., Baffins Lane, Chichester, West Sussex, PO19 1UD, 1995, 449pp, £24.95, ISBN 0-471-95473-X.

Man has sought to make sense of his existence, and that of the universe around him, since prehistoric times but this did not really come about until Einstein advanced his theory of general relativity in 1915 and Hubble convinced the astronomical world of an expanding Universe in 1929.

The question of how cosmic

structures came into being and subsequently evolved has intrigued and engaged both experimental and theoretical astronomers for many years now.

Recent spectacular breakthroughs, such as the 1992 discovery by the COBE satellite of fluctuations in the temperature of the cosmic background, have both increased our understanding and accelerated the pace of research in this area, though still posing the question, "Where did the structure we observe in the Universe around us actually come from?" The Universe is, clearly, very clumpy, with large fluctuations in density in different places caused by gravitational instabilities.

This volume introduces a fascinating and complex subject for advanced undergraduates and post-graduate students. Part 1 provides an introduction to the simplest of cosmological models and basic observational cosmology, while Parts 2 and 3 give a detailed account of the Big Bang Theory and of structure formation by gravitational instability. Part 4 deals with methods of testing theories of structure formation using statistical properties of galaxy clustering, fluctuations of the cosmic microwave background, galaxy peculiar motions, observations of galaxy evolution and of the extragalactic radiation backgrounds.

Teach Yourself Astronomy with Patrick Moore

P. Moore, Hodder & Stoughton Ltd., 338 Euston Road, London, SW3 1BH, 1995, 216pp, £6.99, ISBN 0-340-58597-8.

This is an excellent book at an incredibly low price affordable by even the most impecunious student.

As an astronomical observer of long standing, the author is uniquely equipped to know exactly what is important to the budding amateur astronomer and able to meet all these requirements directly from his own experience.

The book opens with a statement of the basic facts needed to understand the celestial sphere and the amateur's telescope, before moving on to making observations of the Sun, Moon and Solar System and thence to stars of different types, rounding off finally with a number of useful appendices.

Astronomy Selection

Sun, Earth and Sky

K.R. Lang, Springer-Verlag GmbH & Co, KG, Tiergartenstrasse 17, D-69121 Heidelberg, Germany, 1995, 282pp, DM58.00, ISBN 3-540-58778-0.

Whereas only a half-century ago astronomers viewed the Universe solely in visible light, the range of perception has widened today to include the invisible realms of sub-atomic particles, magnetic fields, radio waves, UV and X-rays, all of which have also broadened our vision of the Sun and provided a more complete description of the Earth's environment.

This book records these extraordinary accomplishments, beginning deep inside the Sun where nuclear reactions occur and where particles of antimatter, produced during nuclear fusion, collide with their material counterparts, thus annihilating each other and disappearing in radiative energy. It then peels back the outer layers of the Sun to provide a glimpse both of its internal and its surface oscillations.

The Sun is then considered as a magnetic star, for its visible surface is pitted with dark cool regions (sunspots) where intense magnetism partially chokes the outward flow of heated energy. Sunspots tend to group together in bi-polar fashion, linked by magnetic loops that shape, mould and constrain the Sun's chromosphere.

The sharp visible edge of the Sun is actually an illusion for it is enveloped by a hot, tenuous, million degree and constantly moving gas known as the corona. Observation of this, detected at X-ray or radio wavelengths, show that the apparently serene Sun is in a state of continuous change.

Unpredictable eruptions on the Sun produce outbursts of charged particles and radiation that can affect our lives. Intense radiation from a powerful solar flare travels to Earth in just eight minutes, altering our outer atmosphere and disrupting long-distance radio communication. Very energetic particle can arrive at the Earth within an hour or less and may endanger unprotected astronauts or destroy satellite electronics. Solar mass ejections reach Earth in between one to four days, resulting in strong geomagnetic storms and electrical power blackouts.

The Earth is wrapped in a thin membrane of air that protects and incubates us all and which

acts as a one-way filter, allowing sunlight through to warm the surface but preventing the escape of some of the heat into the cold of outer space. The Sun energises our climate and weather. Over the past millions of years, our climate has been dominated by recurrent periodic ice ages which are mainly explained by the changes in the amount of sunlight reaching the Earth. Smaller and more frequent climatic fluctuations superimposed on these glacial cycles may result from variations in solar activity itself. For instance, when the sunspot cycle effectively disappeared during the latter half of the 17th century, giving a long period of solar inactivity, this coincided with unusually cold spells in the Earth's Northern Hemisphere.

The Guinness Book of Astronomy (5th Edn)

Patrick Moore, Guinness Publishing, 33 London Road, Enfield, Middlesex, EN2 6DJ, 1995, 288pp, £17.95, ISBN 0-85112-643-X.

A good deal has happened in the world of astronomy since the last edition of this excellent reference book appeared in 1992. This new and updated edition contains colour illustrations for the first time and brings events up-to-date with such details as the impact of Comet Schoemaker-Levy 9 on Jupiter, further discoveries by the Hubble Space Telescope, new theories of the origin of the Universe and further data on planetary exploration. The book also includes a comprehensive star catalogue with finder charts, particulars of solar and lunar eclipses up to the year 2006 and potted sections on variable stars, star clusters, nebulae and much else.

The Supernova Story

L.A. Marschall, California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, New Jersey 0818, USA, 1988, 320pp, \$12.95???, ISBN 0-691-03633-0.

A supernova indicates a massive explosion which signals the death of a star. It is believed that this causes a cosmic recycling of the ejected chemical elements and leaves behind a pulsar or a black hole, or, perhaps, nothing at all.

This book describes the life cycles of stars and shows how scientists came to our current understanding of supernovae, piecing together observations and historical accounts to devise a theory which was first tested by the intensive study of SN1987A, the brightest supernova since 1006.

These notices, compiled by L.J. Carter, are not intended to be reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Full publication details are given for each book to enable copies to be ordered from a local bookseller, if desired. The address of each publisher also appears, for many items can now be ordered direct from them. If not, they will supply the address of a local agent who can handle matters.

New Docking Idea

The European Space Research & Technology Centre (ESTEC), a part of the European Space Agency, has just signed a 2½ year contract with the University of Glasgow's Department of Aerospace Engineering to develop a new way for spaceships to meet up in space and dock more safely. If successful, the system would be available for use on International Space Station Alpha, assembly of which begins in 1997.

At present, rendezvous and docking manoeuvres are planned manually from a ground station well before launching. This is because spacecraft computers tend to be more than 10 years behind computers on Earth because they have to be very robust to withstand radiation in outer space. Programming an on-board spacecraft computer to navigate through space and dock neatly at a space station is a very complex procedure.

Researchers in the University's Department of Aerospace Engineering have come up with a simple mathematical idea by which the spacecraft computer could process sensory information and carry out its own path-planning in space. Dr Colin McInnes, who heads up the re-

search team explains:

"Using our method, spacecraft approaching ISSA will be able to rendezvous and dock largely unaided using a new simple on-board method. This will increase the flexibility of operations and reduce both astronaut and ground crew workloads."

When International Space Station Alpha is completed at the turn of the century, ESA's Automated Transfer Vehicles will be needed to ferry water, oxygen and other supplies between the Earth's surface and the station. If the University of Glasgow can prove their new system, which offers flexibility and safety, it will play a key role in the space technology of the 21st century.

Award Winner



Gavin Johnston.

Gavin Johnston, a 1995 Aerospace Engineering graduate of the University of Glasgow, was the only UK winner of a European-wide competition for a place on a European Space Agency Design Workshop.

The competition, organised by the student organisation Euroavia and a number of major European Aerospace companies, provided 25 places at the workshop outside Amsterdam for top European undergraduates. Gavin won his place on the strength of his final year project work on "Lunar Return Aerobraking".

The workshop involved the design of a small lunar satellite to survey potential landing sites for the European LEDA lunar lander programme.

Gavin, who is a member of the British Interplanetary Society, returns to Glasgow this month as a member of the Space Systems research team led by Dr Colin McInnes in the Department of Aerospace Engineering.

Kent Graduates Go To ISU

Two graduates from the University of Kent at Canterbury have become the only British students to join the new, one year Master of Space Sciences (MSS) course run by the International Space University (ISU). The Strasbourg-based ISU was set up in 1987 and is dedicated to the development of outer space for peaceful purposes through international and multi-disciplinary education and research programmes. Simon Challis, who graduated this year with a degree in Physics, and Christopher Stott, who graduated from Kent in 1992 after studying American Politics, will join students from all over the world who have set their sights on a career in the space sector.

Simon Challis has an ambition to design and manage space missions, whilst Christopher Stott, who currently works for a children's charity and acts as special advisor to Lord Russell of Liverpool on space and aerospace issues, is primarily interested in space law and policy. He sees huge business potential in space and is co-author of *A Space for Enterprise* (Adam Smith Institute), which looks at the changing nature of the space/aerospace industries together with government involvement. Christopher also has a sense of destiny about his choice of career as he was born on the day the Apollo Space Mission was launched.

Both Simon and Christopher agree that for too long space has been misused and

mismanaged due to economic and political compromise and it is perhaps not surprising that people see it as a waste of money. Despite this, they say that there have been considerable spin-offs from the space industry, such as the expansion of telecommunications and remote sensing which is used in weather forecasting.

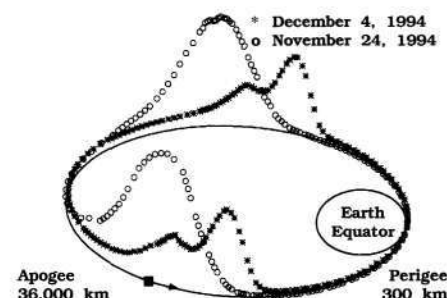
The MSS course combines a wide range of scientific and management factors, taking into account the economic, legal, political and cultural environment of international space programmes. Like all the programmes run by the ISU, it places a strong emphasis on developing an international community of professionals to work together efficiently and effectively whatever their nationality and culture.

New Data Upset Radiation Models

Two British-built spacecraft have survived for more than a year in the harsh environment of the Earth's radiation belts and in the process discovered dramatic new information about them.

The STRV 1a and 1b spacecraft, designed and built in Farnborough by the Defence Research Agency (DRA), were only expected to operate for a year as a result of massive doses of radiation encountered in their highly elliptical orbits.

Now, more than 12 months after launch on 17 June 1994, scientists controlling the spacecraft say they could go on sending back valuable information until 1996.



A three-dimensional plot, around the orbit, showing electron count rates. The data were recorded on two dates by the ESTEC-PSI Radiation Environment Monitor on STRV-1b. The electron belt is seen to move out to higher altitudes and change shape. Also, the density of the belt continuously changes in phase with the 27 day Sun rotation period. The examples plotted correspond to maximum densities observed during the cycle.

PSI/ESTEC

According to mission manager Nigel Wells, the twin spacecraft - which carry a total of 14 experiments in a unique collaboration between the UK MoD, the US Ballistic Missile Defense Organisation and ESA - have not been subjected to the constantly high levels of radiation predicted by internationally accepted scientific models.

"Based on the standard NASA and ESA models of the radiation belts we feared an early failure of the satellites from degradation of the solar arrays - but this has not happened.

"What the STRV experiments have discovered is an enormous time variation - the Earth's radiation belts are far from being constant or static but are very dynamic.

"The biggest surprise was the unexpected time variation and fluctuation. The peak regions of the belts - often called the Van Allen belts after the scientist who first discovered them - move dramatically in and out. There is a correlation with the 27 day rotation of the Sun linked to its active regions."

Communications satellites are generally placed in similar, highly elliptical orbits for a short time after launch before transferring to geostationary orbits 36,000 km above the Earth. The DRA is now talking to potential partners in Europe and the US for follow-on missions to the same geostationary transfer orbit with a target launch date in 1998.

"Voices from the Sky"

The British Interplanetary Society joined forces with NASA and Intelsat to honour Arthur C. Clarke, - the father of modern satellite communications - on the 50th anniversary of the first publication of his ideas on how satellites could be used to transmit communications around the world.

BY CLIVE SIMPSON
BIS Member

The special Society meeting in London made full use of today's communication satellites - the very technology first proposed by Arthur C. Clarke, a past President and life-long supporter of the Society. Taking part were the NASA administrator Daniel Goldin (in Pasadena, California), the Director General of Intelsat, Irving Goldstein (in Washington), Arthur C. Clarke himself (in Colombo, Sri Lanka), and over 200 special guests and Society members in simultaneous live video links between Sri Lanka and the two sites in America, one on the east coast and one on the west. The technology used for the event - billed as *Voices from the Sky* - included four satellites spanning 14 world time zones, seven Earth stations and a variety of terrestrial optical and microwave links.

As well as the NASA Distinguished Public Service Medal and the Society's Space Achievement Medal, Dr Clarke was also presented with special gifts by ERA Technology and the BIS.

Society Fellow and planetary scientist *Dr Garry Hunt* introduced the evening thus:

"This is a special event - an evening to celebrate and honour our most distinguished Society member, somebody known throughout the space community who has done so much over more than 50 years. He has brought to space science, technology and exploration things that we now all take for granted.

"Arthur is at home in Sri Lanka and now we are going to use this technology which he pioneered by his imaginative thoughts years ago to link up and switch live to Colombo.

"Good evening Arthur. As you can hear we have a packed audience and I can assure you London is the hottest place on the planet tonight, hotter than Sri Lanka, Pasadena or Washington DC. Welcome."

Arthur Clarke: "I gather you can see me and I am delighted to be able to address you even though it is rather beyond my usual bedtime. I am indeed honoured and flattered to be able to be present before you electronically in your rather tropical climate."

Garry Hunt: "Part of Arthur's work over the past 50 years has involved a very close link with NASA. Geostationary satellites are fundamental for many aspects of their programmes and Arthur continues to



Dr Paul Thompson, President of the British Interplanetary Society, introducing the presentation of the Society's Space Achievement medal to Arthur C. Clarke

have a wide range of imaginative thoughts about space exploration and the future of space flight. So it is my pleasure to introduce Dan Goldin, the NASA administrator at the Jet Propulsion Laboratory in California."

Dan Goldin: "Dr Clarke it is a privilege to be hooked up with you electronically and we are doing it through an idea that came out of your most productive and fertile mind 50 years ago. As a species we have exploration written into our genetic code - we explored the south pole, the north pole, we went to the Moon, and now it is time to open the space frontier.

"Most of the people in the space programme - including myself - were inspired by your writing. So you are part of us. We need dreamers because dreamers are able to communicate to the people of this planet. Sometimes we engineers and scientists just talk to ourselves and it is important to share the experience because we all want to open the space frontier. You have helped us visualise it.

"But we're also here for a reason - to celebrate your great works and the impact you have had on space exploration programmes. We want to celebrate what you have done for the world, what you have done for space - and we are bestowing upon you the NASA Distinguished Public Service medal, which is the highest medal that any non-NASA employee can achieve. I am proud to give it to you and I would like to read the citation:

'To Arthur Charles Clarke for your continuing contributions over more

than half a century to the exploration and development of space. No writer, living or dead, has done more to demonstrate to the general public the practical value and future potential of continued space exploration.'

"So, on behalf of all NASA employees, the American people whom they represent, and the people who want to break the barriers to open the space frontier, Arthur C. Clarke we honour you. Thank you and congratulations."

Garry Hunt: "We now move on our global trip from the west coast of America to Washington on the east coast. The international telecommunications satellite organisation, known to us as Intelsat, is a commercial consortium of more than 130 countries which owns and operates a global system of satellites to provide worldwide telecommunications services. It is my pleasure to introduce the Director General of Intelsat, Irving Goldstein."

Irving Goldstein: "I am delighted to join all of our colleagues at NASA and the British Interplanetary Society in honouring you, Arthur, as we commemorate the 50th anniversary of your prophetic paper 'The Space Station - its Radio Applications'. This simple, four page memorandum spelled out in elegant detail the promises of geostationary communications satellites and these thoughts were further developed in your famous *Wireless World* article, published in October 1945.

"It seems we have been commemo-

rating a number of 50th anniversaries this year. Some good and some not so good. But I believe this anniversary is one of the most significant. It was just the beginning of what was to become a rich library of writings, some science fact, some science fiction, some science fiction that became science fact. From communications satellites to space elevators your mind has been a treasury of wonderful 'what ifs' that have become 'what ares'.

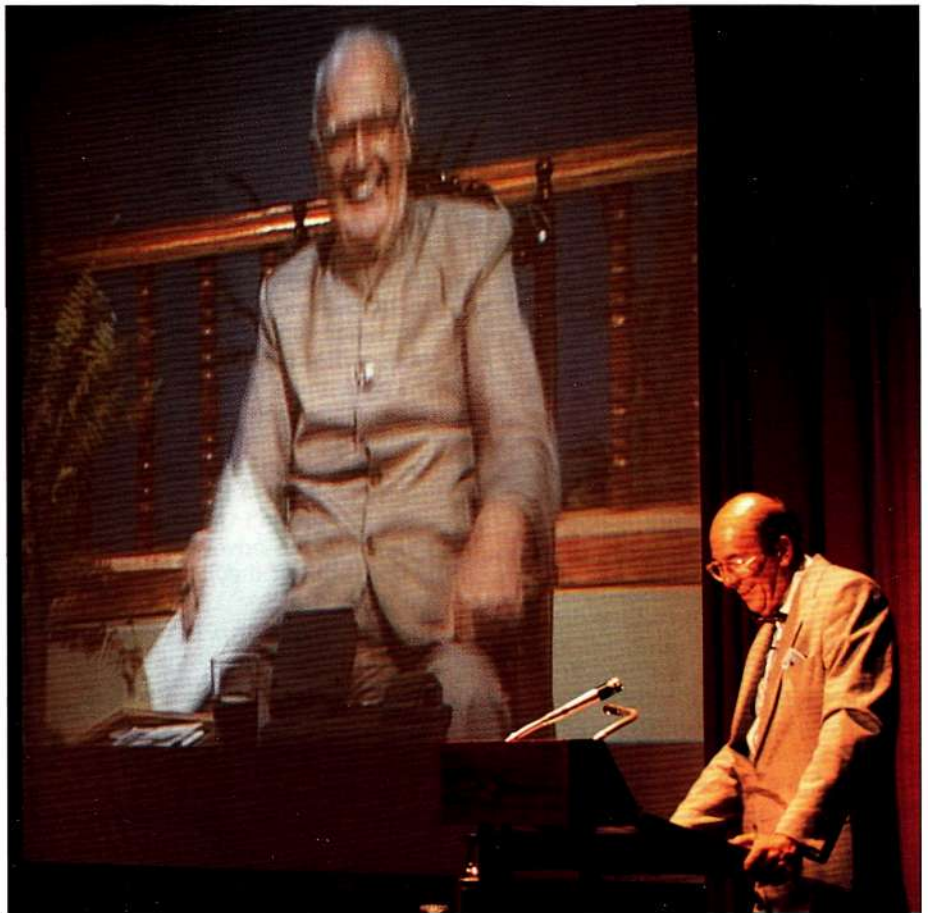
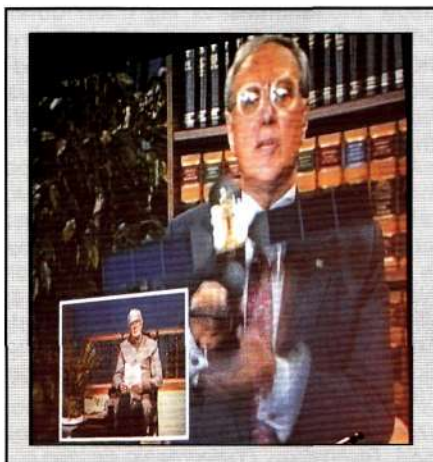
"Of course, not even a science fiction writer and futurist such as yourself could have foreseen the rapid creation, development and operation of a global satellite communication system. Nor its myriad effects on global culture, business and politics. Indeed, writing in February 1945 you indicated that you did not expect a global satellite system to be created for perhaps 50 years. I believe we can all agree that in this case technology moved much more rapidly than science fiction.

"Arthur, your thoughts launched, at least in a figurative sense, the era of satellite communications. You are now recognised world-wide as the father of satellite communications and for your pivotal role in making global satellite communications a reality for people everywhere.

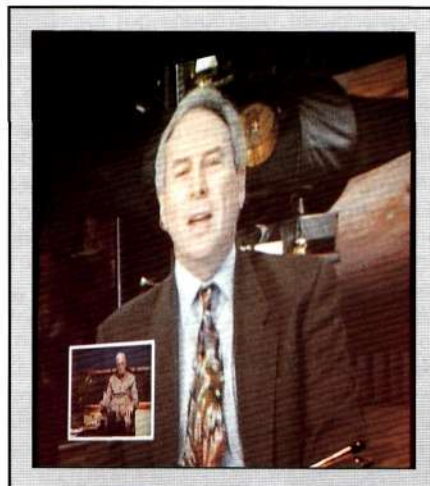
"In a sense you started a communications revolution in 1945. This has enabled the free-flow of information across national borders and brought economic opportunity, health and social benefits to people around the world - you were in effect writing about the information super highway 50 years ago.

"But perhaps just as important is that you have never stopped writing about the potential benefits from progress in communications and space technology. One of your legacies is certainly the promotion of space-based technology for the common good of the world's people. Your creativity and your willingness to share it has guided others by helping them realise the full potential of what could be."

Irving Goldstein, Director General of Intelsat honours Arthur C. Clarke as the father of satellite communications.



Dr Garry Hunt introduced the evening's speakers and is here with Arthur C. Clarke sharing a little amusement to the delight of all present.



NASA Administrator, Dan Goldin announcing the award of the NASA Distinguished Public Service medal to Arthur C. Clarke.

The award by the British Interplanetary Society of its Space Achievement medal to Arthur C. Clarke was made by Society President, Dr Paul Thompson who said:

"I know that you have received many honours for your activities and I am delighted to be able to add your name to the elite group of distinguished recipients, including the Apollo 11 astronauts, of the Society's Space Achievement medal. It gives me even greater pleasure to recognise the great contribution you have made to the British Interplanetary Society over the years, as President and also as an Honorary Fellow. Congratulations and best

wishes from all of us."

After thanking everyone and saying he had never had "quite so many honours on one occasion", *Arthur C. Clarke* went on to address those present in London and America:

"Greetings to my friends on three continents. Let me remind you of a little more history. Nineteen ninety-five is also the centennial of Marconi's first wireless transmissions. And just 100 years ago in 1895 HG Wells also published his masterpiece *The Time Machine* and, six years later, *The First Men in the Moon*. On the latter he had a stroke of luck because, by then, he could include an epilogue inconceivable a decade earlier - his character Cavor could now report back to Earth by 'an apparatus of the Marconi type'.

"The idea of geostationary satellites is even older, dating back to 1869 when Edward Hale published *The Brick Moon*. This developed the amazingly far-sighted idea that a close satellite, bright enough to be visible, would be a superb navigational aid. Now, of course, the global positioning system, though depending on radio instead of light, does exactly that and is far more than the brick moon of Hale.

"Today I became a third part owner of a T-Rex embryo in quite good condition. That reminds me, Larry Niven [in Pasadena], I saw your recent remark that the dinosaurs became ex-



From left to right: Fred Clarke, Dr Paul Thompson and Len Carter, who is himself a recipient of the NASA Distinguished Public Service medal.

tinct because they had no space programme. If Comet Hale-Bopp doesn't fizzle out but fills the sky just 18 months from now we will be hearing a lot more about Project Spaceguard - and I trust we will not become extinct for the same reasons that the dinosaurs did!

"Back in 1945 I assumed that comsats would be large space stations with permanent servicing crews. But then along came the transistor and microelectronics and so Intelsat 1 went into orbit only 20 years after I had described it and not 50 years as I guessed. I sometimes say that the transistor was a disaster for manned - person - space flight. If we were still stuck with vacuum tubes by now there would be hundreds of engineers permanently in orbit.

"Recently, I had the enjoyable task of using satellite links to address both Rupert Murdoch and Ted Turner - though not simultaneously. I gave them this advice on the use and mis-

use of satellite TV. After quoting a British prime minister's famous accusation that the Press enjoyed 'power without responsibility', I went on to say:

"Today the TV screen is more powerful than newsprint and whatever the bean-counters may say responsibility should always be the bottom line. Though I'm opposed in principle to any form of censorship, my stomach is often turned by the hideous violence shown on so many TV programmes. It is no excuse to say that Hollywood is an even worse offender, and I know all the arguments about screen violence providing catharsis and not role models. But you can't have it both ways - if the advertisers really believed that they'd never buy any air time.

I don't believe that a civilisation can advance technically without corresponding moral progress - if the two get out of step it will self-destruct, as indeed ours is in danger of doing.

Which leads me to a rather awesome conclusion. We have had TV for 50 years - therefore, a volume of space containing several hundred suns has been filled with news of our wars, our atrocities and our crimes - real ones and fictional ones, which an alien intelligence might have great difficulty in distinguishing. I conclude from this that there is no, repeat no, superior civilisation in our immediate vicinity. For if there was their cops would already be here, sirens screaming right across the radio spectrum."

"I was very interested to see that a

group of scientists at NASA have now formed the Interstellar Propulsion Society. This gives me a feeling of *deja-vu* - it is just where I came in when I joined the British Interplanetary Society in 1934.

"The IPS is particularly interested in two concepts long popular in science fiction. The first is the 'space drive', a method of propulsion superior to the noisy, dangerous and inefficient rocket. Some recent highly speculative papers on gravity and inertia hint that such a drive may indeed be possible.

"The second concept is even more startling - faster than light travel, generally believed to be completely forbidden by Einstein's theory of relativity. Well, as we science fiction writers



Fred Clarke (left) received the awards on behalf of his brother with congratulations from Dr Garry Hunt.

have often hoped, there may be some escape clauses that Albert never noticed.

"It would be correct to call me a 'hopeful sceptic'. If faster than light travel is indeed possible that makes the 'Where's everybody?' question even more urgent. As Stanley Kubrick and I pointed out, we have not had any visitors here for about three million years...

"Some favour the 'zoo' hypothesis to explain the absence of ETs - they're watching but not interfering. Star Trek's 'prime directive' is a less stringent version of this theory. Well, I just don't believe good zoo-keepers would allow the animals to kill each other and smash up their cages as we are doing. If any ETs are watching dispassionately and doing nothing to help us carbon-based bipeds, I say to hell with them!"

The event's sponsors included NASA, Intelsat, CONUS, BT Communications, SLRC and ERA Technology. The Society is especially grateful to Brian Thomas for his part in arranging the satellite link-up with the various organisations concerned. The meeting was held at The Scientific Societies Lecture Theatre, London W1 on 18 August 1995.

(The photos on pp.362-364 are taken by ERA Technology, Photographic Section.)

Congratulations and Appreciation

Many messages were subsequently received by the Society and are gratefully acknowledged:

Dear Shirley, Just to say how much I appreciate all the good work that you and so many others must have put into Friday's production! I'm delighted that it went so well, and hope that everybody enjoyed it as much as I did.

Really, I can't help thinking that my inability to come to UK made for a much more memorable event!

ARTHUR C. CLARKE

Dear Shirley, May I add my congratulations to the many I know you must have received for the lovely event you organised in Arthur's honour. We greatly appreciate all you have done to give us such a memorable occasion. We will remember the evening for a very long time, and the beautiful trophies you arranged to be presented will long be mementoes of Arthur's work and of the British Interplanetary Society. FRED W. CLARKE

Dear Sir/Madam, I would like to thank the BIS for putting on the excellent tribute to Arthur C. Clarke at the Scientific Societies



A bouquet is presented to the Executive Secretary (Shirley Jones) in recognition of her services in organising the event.

Lecture Theatre. The commendations from Dan Goldin and the head of Intelsat employed well chosen words. It was all quite moving.

STEVE TIDEY

Dear Dr Thompson, I would like to take this opportunity to thank you for your kind invitation to the evening to honour Arthur C. Clarke. The event definitely "made history" and I am very pleased that I could be there to witness it first hand.

D.E. BOOKHAM

Space School

The Brunel School for Space Science

At the 60th anniversary conference of the British Interplanetary Society in 1993, it was announced that the Brunel School would be receiving the endorsement of the Society in promoting its forthcoming programme [1]. A grant from the Society subsequently provided support for a student to attend the week-long August 1994 session. The award recipient was Christopher Barclay who now writes about this course and gives his views on space in general.

The week began in style with a lecture from Heinz Wolff on living in space and the problems associated with this. We then had lectures on the Japanese space industry, the European Space Agency, stars and their different life cycles, propulsion systems and the history of their development, the Solar System, solar sailing, degenerate matter, exobiology, the Jupiter impacts, lunar colonisation plans from the forties and the future prospects of the human race.

Throughout the course we were given plenty of opportunity to ask enthusiastic and intelligent lecturers the questions that we have always wanted to but never had the opportunity before. Whilst one may encounter an adult physicist or mathematician prepared to answer questions and give extra information at school, the chances of finding an aerospace enthusiast are significantly smaller. Thus one is left with only books to refer to about space and many of these are either dedicated to glorifying the Apollo missions or are about the space shuttle. There is hardly any reference to the Russian space programme, next to nothing on the Japanese space industry and, as for the European space industry's documentation, I have yet to see some in a public library.

On the Brunel course one learned that one does not have to be in America to work in the space industry, and that a Russian scientist developed the idea of liquid propellants. Data were given on the European Space Agency, and advice on a variety of fields in which one can do research or seek employment.

It may be a flaw in my character but I fail to see what is so amusing about being interested in space. The situation is further complicated by the lack of public awareness when it comes to the aerospace industry. As mentioned already it is hard to find any useful information about space activities unless one is already established in the aerospace industry, a very relevant example of this being that most of those attending the course only discovered its existence though pure chance (in my case my mother happened to notice the one line of text on three pages of course advertisements that contained the



The group, thoroughly exhausted and still sorting out much newly acquired information, poses for a final photo at the end of the week-long course.

word "Space"). Another topical example was the discovery that half the population of America were unaware of the existence of Mir.

During the week we had the opportunity to share our excitement and enthusiasm for space and the challenge it offers and receive direct tuition on the one subject that seems to escape every curriculum. (I discovered that some astronomy has now entered the GCSE syllabus when I, being the school's official space cadet, was asked to answer a few difficult questions on a prep sheet, the first one read "What is the difference between a star and a planet?" and the sheet eventually worked its way up to asking for a description of the cause of tides. I may sound a little prejudiced but it seems odd that one can call a topic "astronomy" that does not leave our Solar System.)

There were about thirty people on the course so we became close acquaintances even in the one week, and will, I am sure, remain contacts for life. We all shared the same dream to help take mankind from our one fragile home to a place on other planets, perhaps in other solar systems and eventually into new galaxies. We wish to return to the Moon not as temporary visitors sent to act as an advertisement for one nation but as permanent residents supported by a coalition of governments. We think that the only way to solve our problems on Earth is to bring in more raw materials, export some humans (even build the orbiting cities that were designed in the forties) and set up new rainforests and wildlife reserves on other planets. We felt that our race must expand, explore and advance.

BY CHRIS BARCLAY
Space School Graduate

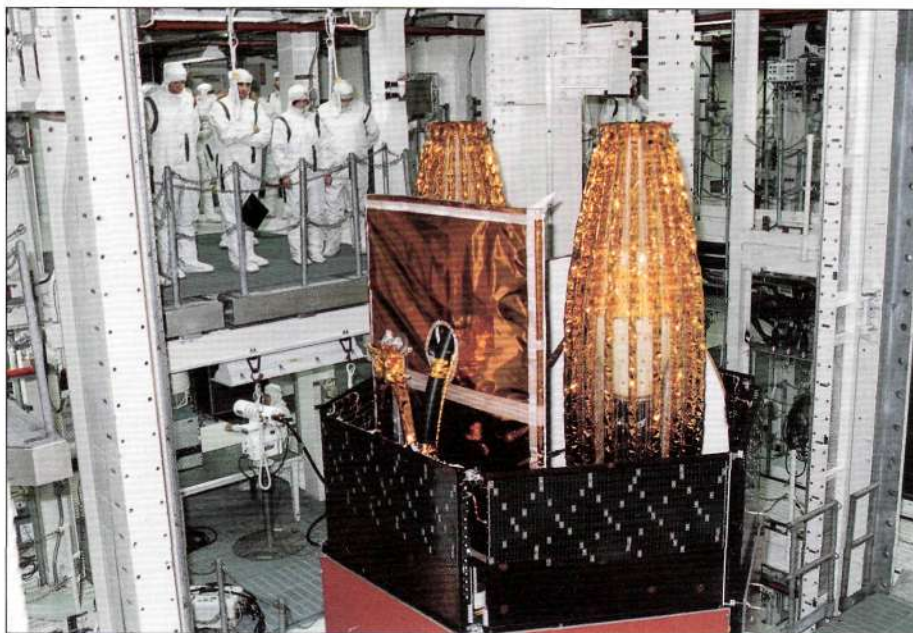
I was asked by someone in my year at school when I thought that technology would stop advancing. The answer, I feel, is that technology will cease to advance on the same day that the human race begins to die. Life is not stagnant, we must continue our evolution. The Brunel space school did not thrust these ideas upon us. Most of us have felt this way for several years but the course did provide us with more information with which to expand our views and fuel our determination to help mankind succeed in his next giant leap. Meeting others who held the same opinions made us realise that we were not freaks or reality challenged. We are simply enthusiastic about our future professions, something that seems out of fashion these days.

Having met and made friends with many like-minded people I am now resolved to put everything I have into the space industry knowing that I am not alone and that I am not wasting my time. We are all determined to follow the final words of Jim Potter, the then course director and a great promoter of the space sciences, "Don't thank me", he said and looking to the sky continued, "make it happen".

Reference

1. Jim Potter, *Spaceflight*, January 1994, p.34.

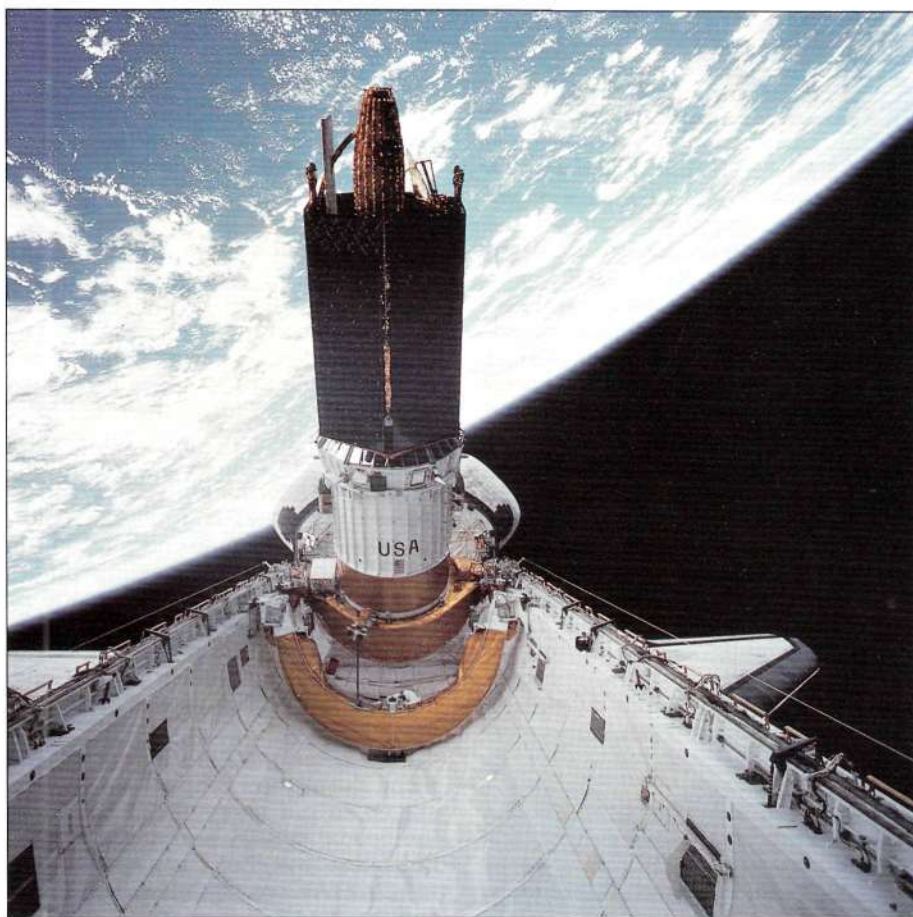
One-page INTO SPACE articles offer readers the opportunity to express their ideas and 'think aloud' on space topics which they see as important and of interest to others. Contributions of an appropriate (one-page) length may be sent to the editor at any time and should be accompanied with a photo of the writer (head and shoulders) and a few lines of personal details.



NASA's Key Spacecraft

Left: Mission Specialists Donald A. Thomas and Mary Ellen Weber inspect TDRS-G during the Crew Equipment Interface Test (CEIT) in the Vertical Processing Facility on 15 April 1995. NASA

Below left: The Tracking and Data Relay Satellite (TDRS-7) and its Inertial Upper Stage (IUS) are captured in this photo at the moment of release from the Shuttle's cargo bay. NASA



STS-70 heads for orbit at 9:42 am EDT on 13 July 1995.

PETER GUALTIERI, WEST KENTUCKY NEWS

Quite spectacular is how Don Thomas described the condensation plume at T+45s as he held a mirror to view it through the overhead windows. The plume started at T+36s, slowly grew, pulsated and dissipated within 20s corresponding to the shuttle passing through "Max Q", the instant when dynamic pressure on the vehicle is maximum.

PETER GUALTIERI, WEST KENTUCKY NEWS

Right: On the morning after the launch, astronaut Don Thomas' twin brother Dennis thanks the booster recovery crews at Cape Canaveral Lock as the Freedom Star tows back the left-hand booster passing only feet from crew relatives and the general public.

PETER GUALTIERI,
WEST KENTUCKY NEWS



Key Satellite in Orbit

New Mission Control in Use at Johnson Space Center

The Space Shuttle *Discovery* was launched from Kennedy Space Center's Launch complex 39B on 13 July 1995 just six days after the landing of *Atlantis* on 7 July. This was the shortest period between a landing and the next launch in NASA's history.

Preparations and Countdown

When the launch of STS-71 was rescheduled for late June, the opportunity arose for STS-70 to be launched first and plans were made to launch on 8 June.

During the first week of April the STS-70 payload which consisted of the IUS-26 booster and the TDRS-G satellite arrived at the KSC Vertical Processing Facility (VPF). The TDRS satellite was built to add to NASA's tracking and data relay capability, the network which provides on-orbit and ground-to-orbit communications relays and which has enabled NASA to close down most of the costly ground stations which had been required for the Spaceflight Tracking and Data Network.

Built by TRW Space and Electronics Group and owned by Goddard Space Flight Center, previous TDRS satellites have been launched on STS-6, STS-51L, STS-26R, STS-29R, STS-43 and STS-54.

The TDRS spacecraft are three-axis stabilised satellites weighing about 4,905 pounds - including about 1,200 pounds of hydrazine propellant. The propellant is used by 24 thrusters for station keeping and positioning. Attitude control is by momentum wheels.

TDRS satellites provide communications services to most of the satellites and Space Shuttles that they support for more than 85 per cent of their orbit. TDRS satellites are positioned at geosynchronous stations 22,300 statute miles above the equator. The communications streams are linked with the ground at the White Sands, New Mexico TDRS ground station.

TDRS-G is planned for on-orbit storage which is less expensive than ground storage. Because of the space agency's critical dependence on the TDRS network, NASA requires two fully functional TDRS satellites and two fully operational reserve satellites. TDRS-G, the last of the seven TDRS satellites built for NASA, will be located at 171°W longitude and becomes redesignated TDRS-7 after taking up its position.

The Inertial Upper Stage used to boost TDRS-G after deployment from *Discovery* was developed and built by Boeing Aerospace Co. The IUS was last used by NASA for TDRS-F during the STS-54 mission in January 1993. The IUS was originally designed as a temporary stand-in for a reusable space tug and was called the Interim Upper Stage. When it was determined that the space tug programme would not be executed the name was changed to Inertial Upper Stage signifying the booster's guidance technique.

The TDRS is attached to the IUS by eight attachment points and the IUS is supported in the Shuttle payload bay by Airborne Support Equipment which holds the IUS in the payload bay, provides electrical and data services to the IUS-TDRS, and elevates the IUS-TDRS into position

BY ROELOF L. SCHULING
at the Kennedy Space Center

for deployment on orbit. The Airborne Support Equipment unit remains with the orbiter after deployment and is removed from the Shuttle on the ground after the flight.



The STS-70 crew patch depicts the Space Shuttle *Discovery* orbiting Earth in the vast blackness of space. The primary mission of deploying a NASA Tracking and Data Relay Satellite (TDRS) is depicted by three gold stars. They represent the triad composed of spacecraft transmitting data to Earth through the Tracking and Data Relay Satellite System (TDRSS). The stylized ribbon represents the American goal of linking space exploration to the advancement of all humankind. NASA

The IUS-TDRS combination was moved to Launch Complex 39B on 2 May and the TDRS-G was fuelled with hydrazine propellant for on-orbit station keeping. Next day it was transported to the Vehicle Assembly Building and mated with the Solid Rocket Boosters and the External Tanks. On 11 May the Space Shuttle was rolled out to Launch Complex 39B to join the payload which was installed on 13 May.

With little more than a week until launch, damage was found to have been caused to the External Tank by woodpeckers digging holes in its thermal insulation.

Discovery was returned to the VAB for repairs and, as it would take several weeks to retest and prepare for launch on its return to Launch Pad 39B, the STS-71 *Atlantis* mission, now on pad 39A, had an opportunity to launch ahead of STS-70. Six days after the landing of STS-71, the launch took place of STS-70 on 13 July. See *Spaceflight*, September 1995, p.314 for details of the countdown and May 1995, p.146 for details of payloads and crew members.

Mission Day One TDRS Deployment

The IUS tilt table was elevated to 29

degrees to point the TDRS/IUS combination out of the payload bay and after "go for deployment" the crew activated the ordnance that separated the umbilical cables and then elevated the tilt table to 59 degrees. A pyrotechnic separation device physically separated the TDRS/IUS from *Discovery* and the TDRS/IUS moved away from the orbiter at about 0.4 feet per second. After the deployment sequence the tilt table was lowered back down to a stowed position.

The deployment came at 3:55 pm (KSC times) and 15 minutes later Mission Commander Tom Henricks fired the Shuttle's engines to raise the orbit and move away from the IUS booster prior to its first-stage firing. One hour after deployment the IUS fired its first-stage engine for approximately 146 seconds for transfer to geosynchronous orbit. After separating the first stage from the second stage of the IUS (and the attached TDRS satellite) second-stage ignition came at approximately 6 hours and 12 minutes after deployment. The second-stage engine fired for about 108 seconds to place the TDRS, now designated TDRS-7, into orbit. The TDRS-7 antennas and solar arrays deployed and the IUS second stage, which had been stabilising the TDRS during these operations, separated from the TDRS and performed a manoeuvre to avoid collision during separation.

New Mission Control

Following TDRS/IUS deployment, flight controllers in the Johnson Space Center vacated their control room and mission control operations moved to a new control room for the remainder of the orbital operations of STS-70. The old room had been in use as Mission Control since the Gemini-4 mission in 1965. The new control room will be able to switch from controlling a Shuttle flight to any other spacecraft with computer menu-selection speed. The commercially available equipment and up to-date technology will also reduce maintenance costs. Present plans are to use the new facility for orbital operations and the old facility for launch and landing operations until early next year. At that stage the new facility will take over all phases of the mission control function.

Mission Day Two

The crew's activities now centred around the science experiments.

- (1) The HERCULES camera which can imprint the latitude and longitude of the areas on Earth being photographed was assembled.
- (2) Mission Specialist Nancy Currie set up the WINDEX experiment which studies the glow effect as Shuttle surfaces interact with atomic oxygen in low Earth

STS-70 MISSION REPORT

orbit.

- (3) The Commercial Protein Crystal Growth (CPCG) experiment operations began as did the Visual Function Tester (VFT) experiment which tests the eye's abilities in microgravity.
- (4) The SAREX amateur radio gear was used to speak with schoolchildren during the day.
- (5) The Military Applications of Ship Tracks unit was used to produce high resolution images of the Earth's surface.

Mission Day Three

Discovery's crew activities centred on experiment operations and also included interviews with Ohio news media. All of the crew, with the exception of Pilot Kregel, were from that state.

Mission Day Four

Discovery continued to perform well with no major concerns.

Pilot Kregel reported that the previous day's difficulty of aligning the inertial navigation system on the HERCULES camera was still present. The crew sent down views of Florida and the Bahamas taken by the camera, which automatically prints latitude and longitude and the camera's sponsors reported that they were delighted with the views.

The Bioreactor Demonstration System (BDS) grows individual cells into organised tissue that is similar to the original tissue. Mission Specialist Weber reported that colon cancer cells growing in the BDS were looking better than those cultured on the ground.

Crew members using the VFT unit reported their eyesight was being affected slightly by weightlessness and it was taking slightly longer to focus their eyes on near objects; an effect which had been noted since early Gemini flights.

The WINDEX experiment was used to make observations during the time that Discovery was firing its small steering thrusters.

The crew reported at least 60 contacts with amateur radio operators around the world by use of the SAREX equipment, including talks with schoolchildren.

Mission Day Five

The crew continued to focus on science experiments. Mission Specialist Currie sent down video images of developing Medaka fish eggs as part of the

An on-board shot of Mary Ellen Weber working with a syringe related to the Bioreactor Development System (BDS). Weightlessness provides the opportunity to grow cells into three-dimensional tissue pieces that are not achievable using conventional tissue culture methods on Earth. NASA



National Institute of Health's Cells division experiment (NIH-C).

Mission Commander Henricks and Pilot Kregel again worked on the alignment of the HERCULES camera. They continued to have difficulty with star alignments, but they had good results in obtaining Earth views and had gathered 95 per cent of the data planned at this stage of the flight. Henricks also fired Discovery's thruster jets in support of WINDEX studies of Shuttle glow.

Mission Day Six

During the morning, the crew reported seeing a small nick on the outside of one of the orbiter's exterior window panes, apparently caused by a micrometeorite sometime during their sleep period. The tiny crater was approximately one sixteenth of an inch in diameter and one thirty-second deep. However, it posed no danger to the spacecraft. The exterior window is a half-inch thick and several additional panes lie behind it. The panes together total two inches of thickness between the cabin interior and the orbiter exterior.

Downlinked images from the DBS unit showed orange colon cancer cells growing into globules as large as a pea. Such units are used on Earth to grow three-dimensional cultures that cannot be produced by traditional culture methods and the DBS was being used to determine how effective such equipment is for supporting growth with minimal cell damage.

The crew activated the Microcapsules In Space-B (MIS-B) experiment for the first time. The MIS-B attempts to produce time-release antibiotic medication in weightlessness. The microgravity environment permits the encapsulation process with greater purity than that of ground en-

capsulation. The device was automatic and operated while the crew slept.

Mission Day Seven

The crew began to wrap up their experimental operations in anticipation of landing on 21 July. They at last successfully aligned the HERCULES camera and sent the ground images from the camera as well as video images of the alignment procedure. After final sessions with the HERCULES and WINDEX equipment they stowed the units away for landing.

Mission Specialist Don Thomas deactivated the MIS-B experiment and also made over 50 contacts with amateur radio operators on the ground with the SAREX equipment. The crew also used the SAREX to talk with a number of schoolchildren throughout the world.

Mission Day Eight

The crew checked out the systems which would be used for the landing at the Kennedy Space Center as is standard practice on the day before landing.

Mission Day Nine

There were two landing opportunities at the Kennedy Space Center on 21 July. However low clouds and fog caused mission controllers to postpone landing until the following day. The crew were advised they would spend an extra day in space after astronaut Steve Oswald flying the weather reconnaissance aircraft advised that he could not see the Shuttle landing runway. The crew therefore climbed out of their launch and entry suits and spent the rest of the day in light duties.

Mission Day Ten

There were two landing opportunities at KSC on 22 July. One 6:26 am and one at 8:02 am. Although the weather looked good for the first opportunity, it was improving and mission controllers chose to wait for the second opportunity.

The deorbit engine burn came at approximately 7:00 am and Discovery glided down to a perfect landing on runway 33. Main gear touchdown was at 8:02:00 am, nose gear touchdown at 8:02:11 am and wheel stop came at 8:02:57 am. Discovery had travelled over 3.7 million miles in an elapsed time of 8 days, 22 hours, 21 minutes and 2 seconds.

After completing its 21st space flight, Discovery was transported to the Orbiter Processing Facility where it will be prepared for its move to California later in the fall to undergo routine inspection and maintenance before its next mission. ■

STS-70 Main Engines

Following the return of Discovery to the Orbiter Processing Facility on 3 February, the STS-63 Space Shuttle Main Engines (SSME) were removed and those planned for STS-70 were installed. The three SSMEs for STS-70 were serial numbers 2036 in the number one position, 2019 in the number two position and 2017 in the number three position. SSMEs 2019 and 2017 are of the current, or "Phase II" SSME design, however 2036 is the first of the upgraded "Block I" design engines.

The Block I engines have improved performance with a new high pressure liquid oxygen turbopump which eliminates all but six of the 300 welds in the current design

and incorporated new silicon nitride ball bearings which are ultrasmooth and harder and lighter than steel. The engine powerhead, which contains the preburners that generate hot gas to drive the turbopumps, has also been improved by replacing three small ducts with two larger ducts which significantly improve fluid flows within the engine. The two duct configuration reduces pressures, turbulence, and maintenance requirements. The new powerhead also has a single-coil heat exchanger replacing the old double-coil design and eliminates seven welds within the engine. (See *Spaceflight*, September 1995, p.315).

Major Launch Failures

In the Early Soviet Space Programme

For the first approximately thirty years of the Soviet space programme, Soviet authorities rarely, if ever, announced orbital launch failures in any programme. This gave rise to much speculation among Western analysts in attempting to portray a realistic account of the early days of the Soviet space programme. Combining fairly unsubstantiated rumours with "leaked" accounts from the Western intelligence community, analysts were forced to rely on at best second-hand information. This major omission can be partially rectified at the present with the help of numerous detailed accounts of Soviet orbital launch failures, covering a wide time period, that have been recently published in the CIS media. This article is an early attempt to combine and integrate some of the recently released information and make a preliminary contribution to a very important aspect of the Soviet space programme.

The article is divided into eight parts, each section describing failures in a particular project.

Sputnik

While there were three successful Sputnik launches, it has been revealed that there was one concealed orbital failure in the programme:

Spacecraft	Launch Date	Launcher	Mission
Sputnik (Object D)	Apr 27 1958	Sputnik	science

According to a report, "resonant frequencies" destroyed the launch vehicle prior to separation of the strap-ons from the core stage [1]. The payload was originally meant to be the first Soviet artificial satellite, but was later replaced by the famous PS-1. The backup Object D was finally launched as Sputnik-3 in May, 1958.

Luna

The automated lunar programme suffered from numerous orbital launch failures in its entire history covering 1958 to 1976, as the following listing shows:

Spacecraft	Launch Date	Launcher	Mission
Luna (E-1 No. 1)	Sep 23 1958	Luna	lunar impact
Luna (E-1 No. 2)	Oct 12 1958	Luna	lunar impact
Luna (E-1 No. 3)	Dec 4 1958	Luna	lunar impact
Luna (E-1A No. 5)	Jul 18 1959	Luna	lunar impact
Luna (E-3 No. 1)	Apr 15 1960	Luna	far-side photo
Luna (E-3 No. 2)	Apr 16 1960	Luna	far-side photo
Luna (E-6 No. 2)	Feb 3 1963	Molniya	soft-landing
Luna (E-6 No. 4)	Mar 21 1964	Molniya	soft-landing
Luna (E-6 No. 5)	Apr 20 1964	Molniya	soft-landing
Luna (E-6 No. 8)	Apr 10 1965	Molniya	soft-landing
Luna (E-6LS No. 112)	Feb 7 1968	Molniya	lunar orbit
Luna (E-8 No. 201)	Feb 19 1969	Proton-K	lunar rover
Luna (E-8-5 No. 402)	Jun 14 1969	Proton-K	sample return
Luna (E-8-5 No. 405)	Feb 6 1970	Proton-K	sample return
Luna (E-8-5M No. 412)	Oct 16 1975	Proton-K	sample return

Details have been released on the nature of some of the failures:

Sep 23 1958:

This vehicle fell apart at T+92 seconds and then impacted on to the ground [2].

Oct 12 1958:

This vehicle exploded after T+100 seconds. The failure of both launches was traced to resonant oscillations that had arisen as a result of adding the Block E stage on the basic R-7 missile. A solution was then proposed to mount damping devices to eliminate unbalanced loads on the vehicle [2].

Dec 4 1958:

There was a failure in the rocket engine of the Block A at T+245 seconds, aborting the mission [2].

Jul 18 1959:

This time a failure of a navigation instrument in the core stage prompted an accidental command to the emergency self-destruct mechanism [2].

Apr 15 1960:

This vehicle's failure was traced to a premature cutoff of the engine of the Block E stage [3].

BY ASIF A. SIDDIQI*

Amherst, MA, USA

Apr 16 1960:

At launch, only three of the four strap-on boosters ignited, and the vehicle deviated from its trajectory soon after launch. All control over the launcher was lost at an altitude of about 150-200 m, and all five boosters inadvertently separated from each other. The first and second strap-ons landed near the launch pad, the third landed only 30-40 m from an observation site, while the fourth also created an explosion at its impact. The core stage meanwhile landed near the Assembly-Test Building causing some minor damage. Finally the Block E stage flew about a kilometer from the launch pad exploding in a salt lake [3].

Apr 10 1965:

This launch is said to have been thwarted by a failure in the Block I stage of the Molniya booster.

Feb 19 1969:

The Proton-K/Block-D booster carrying the first Lunokhod rover was exploded on ground command following a spurious breaking away of the payload shroud; the wreckage landed some 15 km from the launch site [4]. This spacecraft was the first attempted launch of a Luna probe on the Proton-K booster.

Jun 14 1969:

The first three stages of the Proton-K/Block-D booster operated nominally, but the Block-D stage failed to fire, causing the payload to land in the Pacific Ocean [4]. This was the first of two lunar sample return missions attempted by the Soviets in 1969. Both were meant to steal some thunder from the impending Apollo-11 flight. The second sample collector was Luna-15 which crashed on the surface of the Moon in July 1969.

Korabl Sputnik

In the precursor series for the piloted Vostok programme, there were at least two complete orbital launch failures, both carrying dogs:

Spacecraft	Launch Date	Launcher	Mission
Korabl Sputnik (1K n1)	Jul 28 1960	Vostok	precursor
Korabl Sputnik (1K n4)	Dec 22 1960	Vostok	precursor

Details of the failures are given below:

Jul 28 1960:

The strap-on boosters broke away from the core of the Vostok booster just 19 seconds following launch, and there followed a powerful explosion that killed its canine passengers Chaika and Lisichka [5].

Dec 22 1960:

This time there was a premature shutdown of the engine of the Block E third stage [5]. The payload carrying the two dogs Zhemchuzhnaya and Zhulka reached an altitude of 214 km and flew 3,500 km downrange before landing safely by parachute near the impact area of the famous Tunguska meteorite. Both passengers were successfully recovered unharmed.

*The author wishes to thank J. McDowell for information on the Luna programme.

Mars

In the Mars programme, the record shows four complete orbital launch failures that occurred in pairs eight years apart:

Spacecraft	Launch Date	Launcher	Mission
Mars (M1 No. 1)	Oct 10 1960	Molniya	Mars landing
Mars (M1 No. 2)	Oct 14 1960	Molniya	Mars landing
Mars (M-69 No. 1)	Mar 27 1969	Proton-K	Mars orbit
Mars (M-69 No. 2)	Apr 2 1969	Proton-K	Mars orbit

Details of the failures are given below:

Oct 10 1960:

The engine control system failed during firing of the core stage of the booster (what the Soviets called the 2nd stage) due to resonant oscillations of the Block I stage. The booster exploded at approximately T+200 seconds [6].

Oct 14 1960:

This failure was traced to frozen kerosene in the inlet leading to the pumps of the Block I (3rd) stage as a result of a liquid oxygen leak. Subsequently a valve failed, and the payload re-entered the Earth's atmosphere without entering orbit [6].

Mar 27 1969:

One of a series of Proton-related failures that occurred in 1969, the vehicle exploded at T+438 seconds into the launch, due to a fire in the turbine of the engines of the third stage of the Proton-K/Block D [7,9].

Apr 2 1969:

The second and last attempt at a Mars launch in 1969 also failed, although this time the failure was at a much earlier point in the mission. At the instant of launch at T+0.02 seconds, a fire began in one of the first stage engines of the Proton-K/Block D [7]. After rising a short distance, the rocket veered towards the ground and crashed close to the launch site [9].

Early Zond

There were at least two orbital launch failures in the early Zond lunar and interplanetary programme:

Spacecraft	Launch Date	Launcher	Mission
Zond (3MV-1A No. 2)	Feb 19 1964	Molniya-M	Venus flyby
Zond (3MV-1 No. 3)	Mar 1 1964	Molniya-M	Venus flyby

Although details are not known on the nature of the failures, the mission goals are given below:

Feb 19 1964:

This was a Venera craft meant for a Venus flyby [8].

Mar 1 1964:

This was a Venera craft meant for a Venus flyby [8].

Venera

Only one launch failure is known to have occurred in the Venera programme:

Spacecraft	Launch Date	Launcher	Mission
Venera (3MV-2 No. 2)	Nov 26 1965	Molniya-M	Venus flyby

The spacecraft was part of a group of four attempted missions in November 1965 which were meant to reach the planet. Of the four, only two managed to reach the vicinity of Venus, Venera-2 and Venera-3 [8].

Proton

Only one launch failure has been identified in this scientific programme:

Spacecraft	Launch Date	Launcher	Mission
Proton (N-4)	Mar 24 1966	Proton	science

No details are available on the failure, although the attempt has been reported in CIS sources [10].

Zond

There were several failures in the piloted circumlunar programme otherwise known as the UR-500K/L-1 project. It was in fact the spate of failures that seriously delayed the project, and eventually resulted in its cancellation.

Spacecraft	Launch Date	Launcher	Mission
Zond (7K-L1) No. 4	Sep 28 1967	Proton-K	circumlunar
Zond (7K-L1) No. 5	Nov 22 1967	Proton-K	circumlunar
Zond (7K-L1) No. 7	Apr 23 1968	Proton-K	circumlunar
Zond (7K-L1) No. 13	Jan 20 1969	Proton-K	circumlunar

Details of the failures are discussed below:

Sep 28 1967:

The Proton-K/Block D booster was evidently launched with only five of its six first stage engines operating. The launch vehicle remained steady until T+61 seconds, when it finally began deviating from a nominal flight path. The emergency rescue system of the L-1 spacecraft was activated and the booster exploded on command. The remains of the Proton-K impacted about 65 km from the launch site, while the L-1 descent apparatus was safely recovered [11].

Nov 22 1967:

On this occasion, the launch went perfectly, but upon firing of the second stage, only three of the four engines came into operation. For four seconds, the vehicle remained steady, but all engines were then disabled by a safety system. The L-1 emergency rescue system deposited the spacecraft 80 km southwest of Dzhezkazgan, while the booster impacted approximately 300 km from the launch site [11].

Apr 23 1968:

At T+260 seconds into the launch, there was a sudden and unexpected shutdown of the engines of the second stage of the booster. It was later discovered that a short circuit in the control system of the 7K-L1 spacecraft inadvertently resulted in a spurious command to shut off the second stage engines. The spacecraft was however safely recovered [12].

Jan 20 1969:

A failure in one of the four second stage engines prompted the booster control system to abort the mission. At T+501 seconds, the launcher began to deviate from its planned trajectory, and the emergency rescue system was activated. The 7K-L1 spacecraft was recovered successfully. It was discovered later that orbital insertion could have occurred despite the engine failure, but the activation of the safety abort system precluded continued firing of the third stage to compensate for the premature shutdown of the 2nd stage [4].

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7. Lantratov, K., "Jubilees: Russia: 25 Years From the Launches of M-69", *Novosti Kosmonavtiki*, No. 7, March 26-April 8, 1994, pp.43-44.
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9. Aerospace Salon, broadcast on Moscow Ostankino Television First Channel Network, 0820 GMT, June 5, 1994.
10. Petrakov, V. and I. Afanasyev, "Proton Passion", *Aviatsiya i Kosmonavtika*, No. 4, April, 1993, pp.10-12. Note that in the source, the year of launch is incorrectly listed as 1965.
11. Kamanin, L. N., "A Goal Worth Fighting For", *Vozdushny Transport*, No. 47(2179), 1993, pp.8-9.
12. Kamanin, L. N., "A Goal Worth Fighting For", *Vozdushny Transport*, No. 49(2181), 1993, p.8.

'Spacecraft' Competition

Spacecraft are designed to carry out particular types of observations or to serve a particular purpose and this leads to a great variation in their outward appearance. The diagrams below illustrate this point and also give readers an opportunity to win a very attractive prize.

Prize: The first correct entry to be opened after the closing date of 7 December 1995 will receive the 16 inch tall model of the NASA shuttle Columbia pictured on the right. This exquisite model is made from a commercial aluminium alloy and painted to a presentation finish by Robert Tuck, Station Cottage, Kirkby Green, Lincolnshire LN4 3PQ, England and is currently being marketed at £100.00. (Robert Tuck, Artistic Bronze Castings is a manufacturer of polished bronze and painted models of aircraft for the Royal Air Force.)

To Enter: Name each of the three spacecraft illustrated below. The names appear in the following listed details:

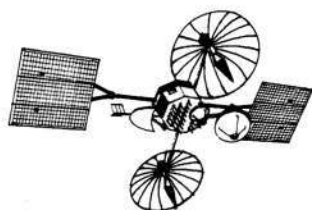
Explorer 28: launched 29 May 1965 to study cosmic radiation, solar wind and the interplanetary magnetic field.

Solar Max: launched 14 February 1980 to study the Sun's atmosphere, solar flares and solar energy.

Landsat 5: launched 1 March 1984 for remote sensing of Earth resources.

TDRS: a Tracking and Data Relay Satellite which serves as a part of NASA's global communications link. The first satellite of the TDRS series was orbited on 4 April 1983.

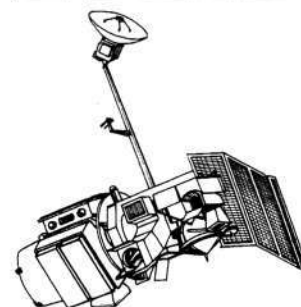
Drawings by Michael Nagel, Naunhof, Germany



A



B



C

Post to: The British Interplanetary Society,
27/29 South Lambeth Road, London
SW8 1SZ, England

To arrive by first delivery on 7 December 1995.

Entries may be submitted on a photocopy or otherwise written out in a clear and unambiguous form.

Title/Name

Address

.....
.....

Spaceflight Crossword

No. 27

ACROSS

1. Two-wheeled vehicle
5. Projects
8. Pertaining to the number eight
9. Vehicle of Space Transportation System
10. Change position
12. Sickie-shaped constellation and sign of the zodiac
13. Decorated
14. Paths in space
17. Stomach
18. Moves from one orbit to another
20. Short curved sword
21. Unoccupied
23. Glances sideways
24. Impact

Solution will appear in the December issue.

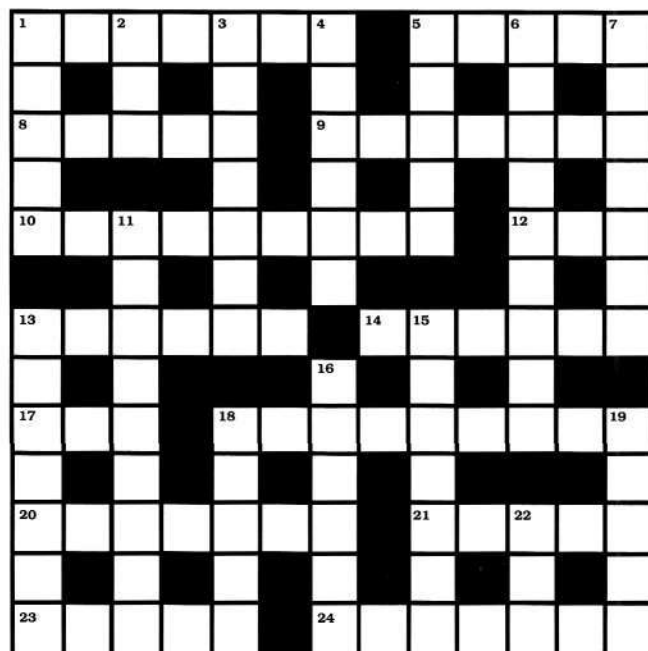
Solution to Crossword No.26.

ACROSS: 1. Nozzle; 4. Upsets; 7. Irregular; 9. Memo; 10. Verb; 11. Agree; 13. Needle; 14. Dredge; 15. Triton; 17. Peptic; 19. World; 20. Rate; 22. Long; 23. Extension; 24. Tastes; 25. Senses.

DOWN: 1. Newman; 2. Zero; 3. Emerge; 4. Unused; 5. Slav; 6. Scobee; 7. Immediate; 8. Rendition; 11. Allow; 12. Erred; 15. Thrust; 16. Novels; 17. Pluses; 18. Cygnus; 21. Exit; 22. Loan.

DOWN

1. Implement that sweeps
2. Feline payload of first Ariane launch ? (acronym)
3. Assemble
4. Develop
5. Line
6. Object that orbits a planet
7. Grieves
11. One thousand millionth of a metre
13. Constructed to operate with light
15. Astrophysicist whose name is given jointly to a well-known diagram
16. Unit of distance measurement for stars
18. Unfreezes
19. Elegance
22. Twenty-first letter of the Greek alphabet



SATELLITE DIGEST-282

Satellite Digest is our regular listing of world space launches. It is abridged from a more detailed monthly listing, *Worldwide Satellite Launches* prepared by Phillip S. Clark and published by the Molniya Space Consultancy.

Spacecraft	Int'l Design.	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Interball 1	1995-039A	Aug 3.00	Plesetsk	Molniya-M	1,250 ?	Aug 6.87	62.90	5,458.17	870	191,752	[1]
MAGION 4/C-2T	1995-039F				58.7	Aug 3.39	63.27	5,454.22	761	191,762	[2]
PAS 4	1995-040A	Aug 4.00	Kourou	Ariane 42L	3,043	Aug 18.83	0.02	1,434.74	35,722	35,798	[3]
Mugunghwa 1	1995-041A	Aug 5.47	ER	Delta-2	1,459	Aug 31.33	0.06	1,436.53	35,781	35,809	[4]
Molniya-3 47	1995-042A	Aug 9.10	Plesetsk	Molniya-M	1,750 ?	Aug 16.31	62.80	718.62	427	39,969	[5]
GEMstar 1		Aug 15.94	WR	LLV 1	127	Failed to reach orbit					[6]
JCSat 3	1995-043A	Aug 29.04	ER	Atlas-2AS	1,820	Aug 30.79	23.22	1,685.13	281	80,799	[7]
N-STAR a	1995-044A	Aug 29.28	Kourou	Ariane 44P	3,410	Aug 30.79	0.09	1,391.64	34,091	35,733	[8]
Cosmos 2319	1995-045A	Aug 30.81	Tyuratam	Proton-4	2,300 ?	Aug 31.65	1.48	1,441.02	35,806	35,960	[9]
Sich 1 + FASat-Alfa	1995-046A	Aug 31.28	Plesetsk	Tsyklon	1,560 ?	Sep 1.36	82.53	97.73	632	669	[10] [11]

NOTES

- Also called Interball Tail Probe, Interball 1 is the first flight of the new Prognoz-M2 scientific satellite "bus". Major international scientific research programme investigating the magnetosphere and plasmasphere: countries involved are Austria, Bulgaria, Canada, Cuba, Czech Republic, ESA, Finland, France, Germany (former GDR), Hungary, Poland, Rumania and Sweden. Associated Interball Auroral Probe is planned for a 1996 launch. Actual launch time was August 2 at 23.59 10.702 seconds GMT.
- MAGION 4 is provided by the Czech Geophysical Institute's Ionosphere Department. Satellite systems were developed and manufactured under international collaboration with Austria, France, Germany, Hungary, Poland, Slovakia, Rumania and Russia. Satellite is studying solar wind energy.
- PAM 4 (PanAmSat 4) is a communications satellite to be operated by the PanAmSat Corporation, Greenwich, Connecticut. Mass of satellite quoted above is at launch: in geosynchronous orbit it is 1,868 kg at the beginning of its life and 1,671 kg dry. Planned location of the satellite is 69°E. Actual launch time was August 3 at 23.58 GMT.
- Mugunghwa 1 (also called KOREASAT 1) is a communications satellite to be operated by Korea Telecom in Seoul. Mass of the satellite quoted above is at launch: on station at the beginning of its life it should have been 833 kg and the dry mass is 641 kg. Orbital location planned to be 116°E. After launch one of the nine solid-propellant Hercules GEM strap-on boosters failed to separate from the Delta 2 first stage and as a result the third stage failed to reach its planned orbit: in making up for the added mass of the GEM the vehicle could only reach an orbit with an apogee about 6,000 km lower than planned. As a result, Mugunghwa 1 had to use its own propellant to raise not just the perigee altitude to geosynchronous orbit (as planned) but also raise the apogee altitude. Because of this unplanned propellant use, the operational lifetime of the satellite is now expected to be approximately 5 years rather than the planned ten years.
- Communications satellite, co-planar with Molniya-3 31.
- Maiden flight of the Lockheed Launch Vehicle 1. GEMStar 1 was planned to provide communications for CTA and VITA ("Volunteers in Technical Assistance"). Planned orbit was 88°, 670 km circular altitude. After launch when the LLV 1 second stage began to fire the launch vehicle veered off-course and had to be destroyed.
- JCSat 3 is a communications satellite launched for Japan Satellite Systems Inc, Tokyo.
- N-STAR a (lower-case "a" is the correct designation) is a telecommunications satellite operated by Space Systems/Loral for Nippon Telegraph and Telephone Corporation, Tokyo. Satellite to be deployed over 132°E.
- "Geizer" communications and data relay satellite, launched as part of the Potok system. Believed to be used primarily for military communications, including space-to-space-to-ground communications with photoreconnaissance satellites. Possibly to be operated over 80°E.
- Sich 1 is an oceanographic satellite built by NPO Yuzhnoye in the Ukraine and a modification of the bureau's Okean-O1 satellite design: mass approximately 1.5 tonnes. Satellite carries infra-red sensors plus a radar system.
- FASat-Alfa is a microsatellite built by Surrey Satellite Technology Ltd for the Chilean Air Force: mass of 57 kg. Carries cameras to image the ozone layer over Chile and a communications package for electronic mail. After launch the satellite should have separated from Sich 1 about six hours after launch, but the separation failed, although the separation command was received by the satellite. USSPACECOM had reserved the international designator 1995-046B for FASat-Alfa in anticipation of it being deployed and tracked as a separate object.

ADDITIONS AND UPDATES

- | | | | |
|-----------|---|------------------------------------|---|
| 1983-026B | Approximately August 3 TDRS 1 stabilised its orbital longitude over 220-221°E. | 182-183°E approximately August 25. | |
| 1984-023A | INTELSAT has now confirmed that INTELSAT 508 has been retired. | 1989-030A | Raduga 23 was manoeuvred off-station over 335°E approximately 1995 August 16 and was still drifting to the east at the end of the month. |
| 1984-114A | Spacenet 2 manoeuvred off-station over 290°E during the first week of August and was still drifting slowly to the west at the end of the month. | 1993-060A | Cosmos 2264 decayed from orbit 1995 August 7. |
| 1985-086B | Optus-A 1 was retired from service in 1993. | 1994-012A | Raduga 31 has not performed any orbital corrections since mid-May 1995 and has now drifted off-station over 44-45°E. It is unclear whether or not the satellite is still operating. |
| 1986-026B | BRASILSAT A2 re-stabilised its orbital location over 267-268°E approximately August 16-17. | 1995-037A | Add the following orbital data for Cosmos 2316: August 8.21, 64.87°, 675.74 min, 19,084 km, 19,176 km. |
| 1987-078A | Optus-A 3 was manoeuvred off-station over 155-156°E approximately August 14 and was still drifting slowly to the west at the end of the month. | 1995-037B | Add the following orbital data for Cosmos 2317: August 9.21, 64.85°, 675.75 min, 19,037 km, 19,223 km. |
| 1987-084A | Cosmos 1888 stopped performing orbital corrections in December 1994 and has drifted off-station over 345-346°E. It is believed that the satellite is no longer operating. | 1995-037C | Add the following orbital data for Cosmos 2318: August 14.37, 64.84°, 675.73 min, 19,037 km, 19,223 km. |
| 1988-040A | INTELSAT 513 had its orbital longitude re-stabilised over | 1995-038A | The name of the satellite should be DSCS-3B 5, not DSCS-3B 4 as shown in last month's issue of "Satellite Digest". |

Continued on the opposite page

SOCIETY ANNOUNCEMENTS

LECTURES

Venue: Lectures will be held in the Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ unless otherwise stated.

Members are cordially invited to attend Society lectures. Admission is by ticket obtainable from the Society. Each member may also obtain a ticket for one guest subject to availability of space. Please send a sae for receipt of tickets.

It may occasionally happen that, for reasons outside its control, the Society has to change the date or topic of a meeting. Where time allows, every effort is made to avoid inconvenience to members either by notice of change in *Spaceflight/JBIS* or by special advice to each participant. Please, therefore, always recheck the scheduled meetings in the latest issue.

1 November 1995 7 - 8.30 pm

Mini Black Holes

Bernard Carr

Queen Mary & Westfield College

Small black holes may have formed in the early Universe when the density was very high. Such primordial black holes are of particular interest because they are the only ones small enough for quantum effects to be important, those smaller than 10^{15} g having evaporated by now as a result of the Hawking process. We discuss their possible observational consequences.

22 November 1995 7 - 8.30 pm

SAREX

Mr Will Marchant

The Shuttle Amateur Radio EXperiment (SAREX) is an amateur radio station flown on about half of the NASA Space Shuttle Missions. It is primarily used for contacts between the astronauts and school students during the mission. The speaker will present a SAREX related slide set that he has created for use by NASA Educational Personnel.

Change of Date

6 December 1995 7 - 8.30 pm

Space, The Medical Challenge

Dr Mike Harrison, *DRA Centre for Human Sciences, Farnborough*

Radiation, vacuum and absence of gravity combine to make space an environment that is overwhelmingly hostile to life. Add confinement and isolation in a fragile habitat, a vulnerable life support system, and the remoteness of help and rescue, and you have the ultimate human challenge - the permanent occupation of space. The talk addresses some of the key medical issues involved in responding to that challenge.

7 February 1996 7 - 8.30 pm

GEO, ICO, LEO, MEO: The Alphabet of Emerging Satellite Communication Explained

Recent events have led to a plethora of acronyms for mobile satellite communications systems. The speaker will explain the background of these and compare and contrast the emerging systems in this dynamic application of space technology.

SYMPOSIA

27 March 1996 10 - 4.30 pm

Call for Papers

Space Transportation

For over a decade the BIS has run symposia on the subject of space transportation. These are intended to provide a forum to cover all aspects of the space infrastructure including the rationale for infrastructure development, system concepts and technology issues. In the past these symposia have been key to the development of HOTOL, Skylon, the Polar Platform and UK thinking on space industrialisation as a part of mankind's future.

Organiser: Mark Hempell

1 June 1996 10 - 4.30 pm

Soviet/Russian/CIS Astronautics

The Society is holding the 11th Symposium on the Soviet, Russian and the CIS space programmes. It is acknowledged as one of the foremost meetings to review current and historical programmes. It attracts Fellows and participants from all over Europe and the United States. Advanced registration is necessary and application forms can be obtained from the Executive Secretary. Please include an SAE.

14 - 20 July 1996

Cospar '96 Commission F Assembly

The next biennial assembly of COSPAR, the international Committee for Space Research, will take place in Birmingham. These biennial Commission F conferences (the last was held in Hamburg in 1994), provide one of the most important forums for the discussion of the present status and future directions of space research.

In recognition of the part BIS has played over the past decade in publishing scientific research papers on the relatively new and now rapidly evolving subject of planetary environmental engineering - terraforming - the Society has accepted the invitation of COSPAR to co-sponsor the F3.4 symposium. The organiser of the programme of the symposium *Implanting Life on Mars* is Prof. Robert H. Haynes (President of the Royal Society of Canada) and it is scheduled to be the three hour evening session of the opening day of the conference July 15, 1996.

Fuller details will be published at a later date.

The Society's Library is open to members on the first Wednesday of each month (except August) between 5.30pm and 7pm. Membership cards must be produced.

CLASSIFIED ADS

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WANTED - Apollo Preliminary Science Reports - Tel. (UK) 01782 612808.

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'Apollo 13 Mission' Competition Winners

Winners to whom a video prize will shortly be dispatched are:

Mr J.G. Aase	Haakonvern, Norway
Mr R. Belsten	Bristol, UK
Ms B. De Wilde	Gent, Belgium
Mr G. Buckley	Lancs, UK
Mr M. Cowell	Surrey, UK
Mr P. Wellburn	Edinburgh, UK

The correct answers are: 1. B; 2. C; 3. A.

ADDITIONS AND UPDATES

MOLNIYA-M LAUNCH VEHICLE UPPER STAGES

The Worldwide Web Home Page for the Keldysh Institute of Applied Mathematics (KIAM) carried detailed numerical data for the Molniya-M launch vehicle used for the Interball 1 mission. The dry mass of the third stage (Block I) was 1,976 kg and that for the fourth stage (Block 2BL-SM2) was 896.7 kg. The other object which is always tracked in low Earth orbit is designated by KIAM as the "Launching Provision Block" ("Blok obespecheniya zapuska", BOZ) and this comprises the assembly with the solid propellant ullage motors which are fired just before the fourth stage main engine to settle that stage's liquid propellant in its tanks: the mass of the BOZ was 328.7 kg (it is unclear whether this mass includes the solid propellant or whether it is the burn-out mass).

The Block 2BL is known to have been used for the launches of "Oko" early warning satellites into Molniya-type orbits: the fourth stage cur-

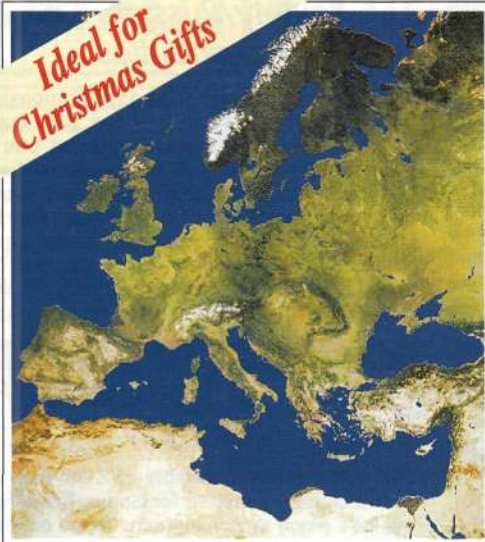
rently used for Molniya satellite launches is the Block ML and it is likely that this has essentially the same mass as the Block 2BL.

"STRELA-1" COMMUNICATIONS SATELLITES

"Strela-1" is the name given by the Russians to the small communications satellites which were launched in groups of eight using the Intermediate Cosmos launch vehicle into near-circular 1,400-1,500 km orbits inclined at 74 deg to the equator starting in 1970. Nicholas L Johnson of Kaman Sciences Corporation was shown one of the satellites during a recent trip to Russia. The satellite is a spheroid with an "equatorial" belt of solar cells and further strips of solar cells running from the "equator" to the "poles": the top of the satellite carries an array of antennae. The size of the satellite is about 1 metre diameter and the description of the satellite states that the mass is 61 kg.

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